SIXTEENTH REPORT

OF THE

STATE ENTOMOLOGIST

OF

MINNESOTA

TO THE GOVERNOR

FOR THE YEARS 1915 AND 1916

TENTH REPORT OF F. L. WASHBURN

AGRICULTURAL EXPERIMENT STATION
ST. ANTHONY PARK, MINN.
DECEMBER 1, 1916

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REPORT OF WORK OF STATE ENTOMOLOGISTS' DEPARTMENT 1914-1915 and 1915-1916

ST. PAUL, MINN.,

His Excellency, J. A. A. Burnquist, St. Paul, Minn.

December 1, 1916.

DEAR SIR: Complying with the law I herewith submit to you the Sixteenth Report of the work of the State Entomologist's Department from December 1, 1914, to December 1, 1916. The financial statement covers the fiscal years from August 1, 1914, to August 1, 1916.

The correspondence of the State Entomologist has increased yearly, our annual average is over 7,000, calling for much time and attention on the part of the clerk and stenographer. Publications have been continued. "Insect Life," edited for the purpose of acquainting farmers, orchardists, gardeners and housekeepers with methods of control of injurious insect pests, has been issued at regular intervals during the two years. Page 6.

The work in Nursery and Orchard Inspection is discussed under Report on Nursery Inspection. Page 28. Our co-operation with the Federal Board in the matter of examining stock imported from Europe has added materially to our responsibility and work.

Illustrated circulars on birds and publications on insects have been printed and distributed from time to time. Work with field mice has been continued, the more common species of the state collected and their life history and habits studied. Certain measures of control are recommended. Progress is being made in our work on bees, ants and wasps in their relation to the farmers, and we will be in position to publish results of this work before long.

The Entomologist has given several lectures (page 7) during the biennium, attending in June, 1915, the annual meeting of the National Nurserymen's Association in Milwaukee, and at Albany, N. Y., in November, 1916, representing, with others, Minnesota at a conference of workers from other states on White Pine Blister Rust. Work with the White Pine Blister Rust, on account of the legal machinery under which the State Entomologist works, has

taken up a large share of my time during the summer of 1916. For details of this work see page 12.

Administration work in connection with the Entomologist's office requires a large share of his time and attention.

The life history of the oak tree girdler has been completed and some interesting facts obtained. Work on flat-headed and round-headed borers is progressing. The forms closely related to the ordinary oak borer are being studied most carefully. Mr. Ruggles' most important work in spraying was done in co-operation with orchardists and potato growers. Citizens are beginning to realize the importance of this phase of fruit growing and are very anxious to obtain the best methods of procedure. The insect collection has been added to, but on account of lack of funds has not been worked upon as it should be for the best results.

We have obtained some interesting data concerning honey bees and insecticides, but this work has only just begun. The life history of the strawberry weevil in Minnesota has been completed by Mr. Marcovitch and we have found a very satisfactory method of control. One of the most important insects of raspberries, the raspberry fruit worm, has been studied and several interesting new points in its life history have been discovered. The work on the wheat stem maggot (Mr. Williamson in charge) is still in progress. Study of the white grub is practically completed and an extension letter has been published on this subject. About 150 breeding experiments have been carried on in the Insectary by the different men of the department.

Flies. The study of the house fly has been continued throughout the two years. This study applied especially to the house fly under rural conditions. Very many observations have been collected on the life history, habits, connection with disease transmission, etc., under farm conditions. A special study was made upon the method by which the house fly passes over the winter. This is one of the few points in the bionomics of the house fly, which has not been elucidated. This phase of the work is still going on, but will probably be completed the coming season, at which time results will be published. A large exhibit was prepared, partly from State Entomologist's funds and partly from University funds, showing how to control the carrying of disease organisms in such places. This model of a "Sanitary Farm," as it was called (constructed under the direction of Mr. Howard), has been in considerable demand, being exhibited twice at the State Fair and at three county fairs. It will be used again during the next two or three years for

exhibit at County Fairs. A leaflet on the control of flies was printed from State Entomologist funds to be distributed when these models were exhibited.

Stomoxys calcitrans. The biting stable fly is one of the most important insect enemies of stock and as such has been given considerable study. This was especially needed because of the suspected connection of this fly with the transmission of such diseases as swamp fever of horses and infantile paralysis of man. The study of this fly is not yet completed, but will be continued during another year.

Culicidae. There is a growing demand in Minnesota for information regarding the mosquitoes of the state, both because of their annoyance to man and as pests to our domestic animals. Two years ago mosquitoes were so numerous that they were quoted as the reason for increasing the price of milk. Extensive studies are under way to determine exactly what mosquitoes are present in every part of the state, their life history and habits and best methods of control. A report containing all the information that we have to date has been prepared for publication in the biennial report of the State Entomologist.

Tabanidae. Horse flies are the most troublesome insect enemy of domestic animals in the northern half of Minnesota. They appear during the first half of the summer in enormous numbers and cause heavy losses to those attempting to conduct dairy farms in that part of the state, in some places holding back the development of the dairy industry almost completely. Mr. C. W. Howard has gathered considerable information about these flies, mostly in the way of finding what species we have, what time of the summer they appear, and in what types of country they are usually found. We are ready to continue this work by studying their life history in detail; in this way seeking for some weak point at which they can be attacked. Also in searching for some material which can be applied to the skin of animals and will act as a repellant to keep the flies from biting them. Nothing has been found yet that has been suitable or cheap enough to be practical for the farmers to use.

Chigger Mites. Detailed study has been given to two species of mites, which were thought to be possibly the adults of "chiggers." Careful study has been given to these mites as pests of wild game birds. The work has progressed so far that it seems now that we will be able to complete it during the coming summer. As soon as the life history of the mite is completely worked out we will be in a position to recommend remedial measures. We have been slow in prosecuting the above subjects because of the small amounts

of money at our disposal and because of the increasing number of new problems brought to our attention each year, which require immediate investigation in order to give the needed assistance to the residents of the state. The control of the cabbage maggot by means of poisoned sprays has been accomplished, and extension letter issued on same.

The fumigation of greenhouses with hydrocyanic acid gas and the factors which insure success have been experimented with by Mr. Moore. Much progress has been made in study of the factors causing injury to plants, but further work is needed during the next two years. See page 93. The study of various chemicals to determine their insecticidal value has already led to the discovery of various benzol derivatives which may be used to fumigate animals to destroy their external parasites without injury to the animal.

PUBLICATIONS.

1915-16.

The following circulars have been published by the State Entomologist's Department in 1915-1916:

Circular No. 34, Dec. 15, 1914, The Cucumber Beetle. C. A. Sell, pp. 6, illustrated.

Circular No. 35, Jan. 15, 1915, Further Observations on Minnesota Birds; Their Economic Relations to the Agriculturist. F. L. Washburn, pp. 24, illustrated.

Circular No. 36, Jan. 30, 1915, The Red Rose Beetle. S. Marcovitch, pp. 6, illustrated.

Circular No. 33, Sept. 1, 1916, Control of Flies in Rural Districts. Revised Edition. C. W. Howard, pp. 14, illustrated.

Circular No. 37, Feb. 1, 1916, Entomologist's Report on Inspection of Minnesota Nurseries and Imported Nursery Stock for the year 1915. F. L. Washburn. pp. 20, illustrated.

Circular No. 38, April 4, 1916, Index, Minnesota State Entomologist's Reports. O. J. Wenzel, pp. 40.

Special Bulletin No. 8, July, '16 Some Insect Enemies of Corn. Warren Williamson. pp. 13, illustrated.
Agricultural Extension Bulletin
State Entomologist's Circular No. 39.

Circular No. 40, Nov. 15, 1916, Work on the White Pine Blister Rust in Minnesota, 1916. F. L. Washburn. pp. 19, 1 colored plate, illustrated.

MINNESOTA INSECT LIFE.

April 1, 1915, Vol. III, No. 1.
May 1, 1915, Vol. III, No. 2.
June 1, 1915, Vol. III, No. 3.
July 1, 1915, Vol. III, No. 4.
Aug. 1, 1915, Vol. III, No. 5 and 6.
April 1, 1916, Vol. III, No. 6 (should be changed to 7).
May 1, 1916, Vol. III, No. 7 (should be changed to 8).
June 1, 1916, Vol. III, No. 9.
July 1, 1916, Vol. III, No. 10.
Aug. 1, 1916, Vol. III, No. 11 and 12.

These numbers of "Insect Life" contain articles on Orchard Insects and Spraying, Apple and Plum Insects, Truck Crop Insects, Warble Flies, Hessian Fly, House Fly, Rabbits, Gophers, Field Mice, Bridge Grafting, The English Sparrow Pest, Tree Tanglefoot, Moles, Woodchucks, Clothes Moth, Stalk Borer, Plant Lice, White Grubs, Currant Worms, Canker Worms, Buffalo Moth or Carpet Beetle, Chiggers, The Raspberry Fruit Worm, The Red Rose Beetle, Birds, Potato Beetles, The Corn Root Louse, The Strawberry Weevil, Mosquitoes, Flies, Woodbine Caterpillar, White Pine Blister Rust, Paradichlorobenzene, Stalk Borers, etc.

Minnesota Nursery and Orchard Inspection News Letter.

Vol. I, No. 1, Sept. 1, 1915.
Vol. I, No. 2, Dec. 6, 1915.
Vol. I, No. 3, April 20, 1916.
Vol. I, No. 4, May 29, 1916.
Vol. I, No. 5, June 18, 1916.
Vol. I, No. 6, Sept. 15, 1916.

The News Letter, issued at irregular intervals by the Entomologist, purposes to convey to Minnesota Nurserymen news items concerning current work of inspection and interesting facts regarding nurseries, in so far as they relate to our work and are of value to nurserymen.

LECTURES.

The following lectures were given by the Entomologist during 1915-1916:

1915.

March—Minnesota Garden Flower Society, St. Paul: Birds.
June—National Nurserymen's Association, Detroit Mich.: Nursery Inspection Problems.
August—Association of American Cemetery Superintendents, Minneapolis: Birds and Insects in Cemeteries.
December—Minnesota Horticultural Society, Minneapolis: Nursery Inspection.

1916.

January—Blake School, Minneapolis: Mimicry in Insects.
March—Farmers' Club, Excelsior: Nursery Inspection; Injurious Insects.
March—Stillwater School, Stillwater: Birds.
April—Fairbault Study Club, Faribault: Birds.
June—National Nurseryman's Association, Milwaukee, Wis.: White Pine Blister Rust.

We wish to acknowledge your interest in the work and encouragement, and to testify to our appreciation of your helpful co-operation and that of the State Treasurer and State Auditor in the campaign against the White Pine Blister Rust. We have also received much aid from the Attorney General's office.

Respectfully,
F. L. WASHBURN,
State Entomologist.

FINANCIAL STATEMENT FOR FISCAL YEAR, AUGUST 1, 1914 TO AUGUST 1, 1915.

Cash on hand		$78.49	
Appropriation		6,300	
			$6,378.49
Biennial Report		$978.11	
Clerk and accountant		825.00	
Express and freight		10.22	
Field mice experiment		179.30	
Field work		6.80	
Labor, assistants, etc		79.35	
Miscellaneous (printing, books, periodicals, etc.)		450.99	
Postage		152.00	
Salaries—			
William Moore	$1,000.00		
O. J. Wenzel	164.66		
S. Marcovitch	735.00		
		1,899.66	
Section budgets—			
Spraying and tree insects	$355.90		
Parasitic insects and field crop pests	136.00		
Truck crop and greenhouse insects (including general insectary work)	833.18		
		1,325.08	
Stationery, office and photographic supplies, etchings, etc.		204.97	
Telephones and telegrams		38.12	
Travel		108.61	
			$6,258.21
Balance			$120.28

FINANCIAL STATEMENT FOR FISCAL YEAR, AUGUST 1, 1915, TO AUGUST 1, 1916.

Appropriation	$6,300.00	
Balance brought forward from 1914-15	120.28	
		$6,420.28

Expenses.

Apparatus	$331.26	
Clerk, account and stenographer	975.03	
Etchings, drawings, photographic supplies and color printing for report	382.30	
Entomological periodicals and library	32.03	
Expenses of assistants	295.17	
Freight and express	15.86	
Insecticides and chemicals	185.43	
Laboratory supplies	47.52	
Nursery inspection	204.58	
Office supplies	88.04	
Postage	183.00	
Printing and stationery	512.59	
Salaries of Assistant Entomologists and other assistants	2,816.61	
Telephones; long distance and telegrams	66.28	
Traveling expenses of Entomologist	95.22	
Working expenses and miscellaneous supplies	181.36	
		6,412.28
Balance		$8.00
Credit July 18, 1916, a/c trees removed		30.00
		$38.00

WORK ON THE WHITE PINE BLISTER RUST IN MINNESOTA, 1916.

F. L. WASHBURN.

(From Special Report and Circular 41.)

Dear Sir: As you are aware the State of Minnesota is unexpectedly threatened by a plant disease, which is a menace, not only to the white pine timber now standing, but also to the cause of reforestation, upon which we place so much dependence for our future welfare, as well as to all five leaf pines used for ornamental purposes in various parts of the state, particularly upon the estates in the neighborhood of our towns and cities. Another aspect in which we must view this unexpected infestation is that concerned with the nursery business and allied interests, since should this disease become widespread, a quarantine might be imposed upon all exports of certain shrubs and trees.

The disease referred to is known as the White Pine Blister Rust *(Cronartium ribicola* Fischer or *Peridermium strobi Kleb.)* This is a fungus parasite with two separate and distinct hosts, the white pine primarily and other five-leaf pines, limber pine *(P. flexilis)*, stone pine *(P. cembra)*, both found in varying abundance in Minnesota nurseries, and used thruout the state as ornamentals, as well as about seven other varieties occurring in various parts of America. The other host upon which it is found during the summer months is the genus *Ribes*, containing as now constituted, both currants and gooseberries, wild and cultivated. Details of this relationship in the life history of the fungus are given below. The disease is of European origin, and was imported into this country on pine seedlings as early as 1900 or earlier. In 1909 large numbers of these were brought to America. (U. S. Dept. of Agr. Farmers' Bulletin 742, Spalding.) The original home of this rust is said to be Eastern Asia or Serbia, spreading thence to England and northern and central Europe. The principal infestations in this country evidently came from Germany.

The foreign seedlings referred to above were widely distributed before it was known that they were diseased; New York, Pennsylvania, Connecticut, New Hampshire, Vermont, Massachusetts, as well as Ohio and Indiana received trees of this sort and in these states the rust

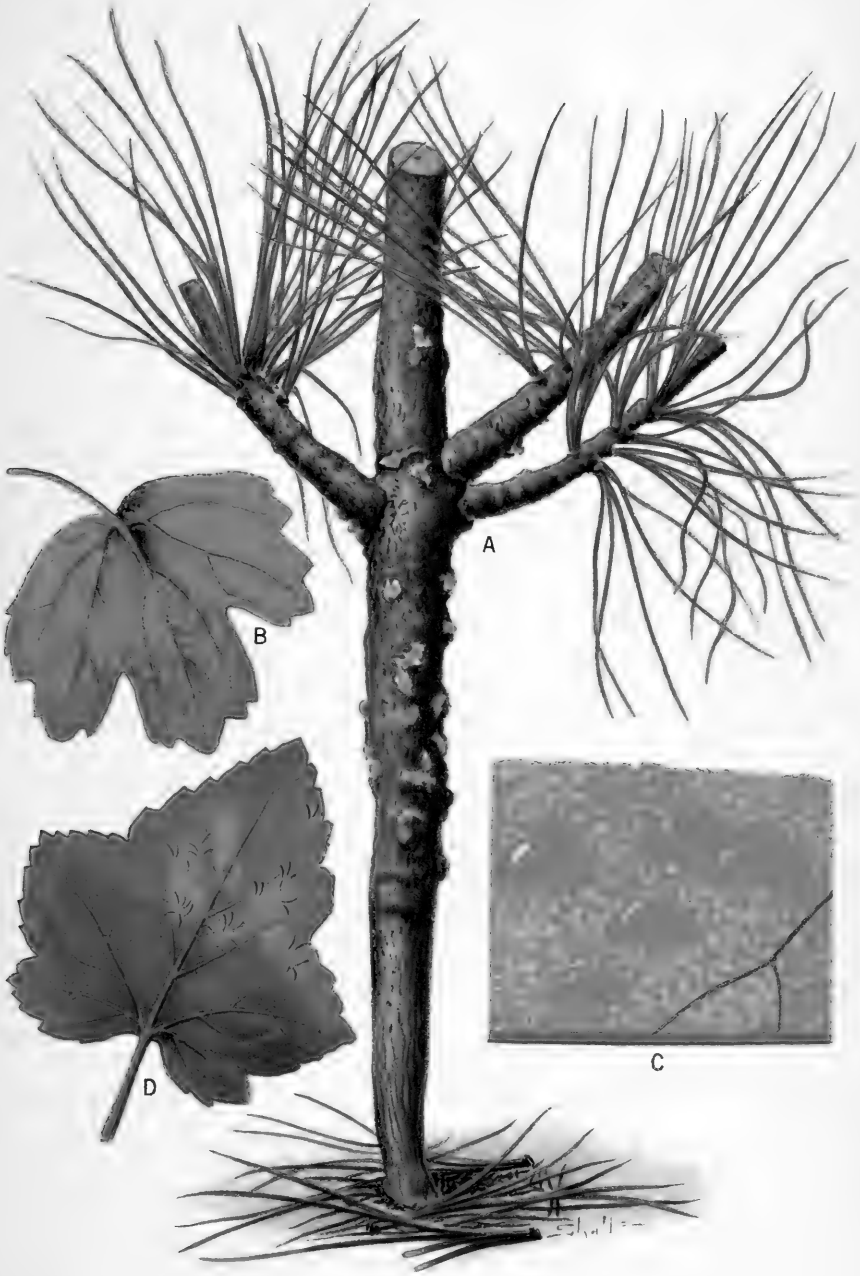
EXPLANATION OF PLATE I.

A. Diseased white pine with blisters broken open, spreading the disease to any currants or gooseberries in the vicinity.

B. Early summer stage on lower surface of currant leaves, repeating on currant leaves or gooseberry leaves during the rest of the season, and a new crop of spores appearing every two weeks.

C. Early summer stage much magnified.

D. Late summer and fall stage on lower surface of a currant spreading the disease back to neighboring pines. Courtesy of Bureau of Plant Industry, U. S. Dep. of Agriculture.



THE WHITE-PINE BLISTER RUST.

became established. It is now (October, 1916) reported as occurring in New Jersey also. To prevent further introduction of the disease into this country the Federal Horticultural Board has forbidden (May 21, 1913) the importation of all five-leaf pines. This quarantine superseded that of September 16, 1912. It did not, however, quarantine any of the above infected states from which pines had been freely shipped, and currants and gooseberries are still allowed to enter the United States from Europe and other foreign countries. The entrance of these canes is doubtless permitted, because it has yet to be definitely established that the rust spores pass the winter upon them.

LOCALITIES IN MINNESOTA WHERE WHITE PINE BLISTER RUST IS KNOWN TO OCCUR.

In May a professor in Macalester College, St. Paul, Minnesota, submitted to the Experimental Station, a portion of a diseased pine coming from his farm in Polk County, Wisconsin. This was at once determined by our Plant Pathologist to be White Pine Blister Rust. Incident to a visit in the latter part of May to St. Croix Falls, Wisconsin, upon the part of members of the Plant Pathology Division and a member of the Nursery Inspection force, the disease was also found in a Minnesota nursery (which, to avoid personal reference we will designate as "Nursery A"), close to the St. Croix River, the proprietor of which had in the spring of 1915 obtained white pine trees at an old nursery in St. Croix Falls, Wis. This last named nursery had purchased these pines in one of two shipments, or in two shipments of trees from Germany, coming thru an Illinois firm in 1908-09.

Later, July 14th, two experts employed by the State Entomologist scouting for the disease along the banks of the St. Croix discovered its presence upon *Ribes* in the timber at Dry Creek, about 6½ miles above Taylors Falls, a mile or more from the St. Croix River, and approximately four miles from the above mentioned nursery designated as Nursery A. Previous to this finding it had been discovered (June 4th) by the Nursery Inspection force in a row of large pines about eighteen years old in a nursery forty miles or more south of the above infested locality. (This nursery may be designated as "Nursery B.") It was found on currants (uredospore stage) growing 75 feet from these infected pine on June 20th.

It is important to note at this point a fact which will be referred to later that, as a result of a most careful investigation by the inspection force upon pines in the early summer and later upon pines, currants and gooseberries no evidence of this disease has been found in other

nurseries, and all primary infestations so far discovered occur within two miles of our eastern boundary. This is important in considering the possible source of Minnesota's infestation. Up to date this disease has not been discovered in this state west of the Mississippi River, except on a few pines shipped from Nursery A and destroyed before blisters appeared.

On September 25th, 1916, Mr. Coe, a field worker in connection with this disease, employed by the State Entomologist, and Mr. Salmon, working for the U. S. Bureau of Plant Industry, found in the course of a blister rust survey of the St. Croix reigon between Stillwater and Taylors Falls, a fourth "center" of infestation upon wild currants and gooseberries, close to the St. Croix at a point known as Pine Hollow Creek, three miles below Osceola on the Minnesota side. This discovery was made so late in the season that leaves were already falling and any attempt towards eradication would have been futile. Many of the pines at this point are undoubtedly now infested. This infestation appears most serious. It was first reported as covering an area of about thirty-five acres, but was later roughly estimated as covering fifty acres. Both here and at Dry Creek the deciduous growth is mingled with pines of various sizes. The latter place has a magnificent stand of large white pines, representing many thousand feet. In both localities pines, currants and gooseberries occur abundantly in ravines of varying width and length, and in these localities the disease was found most abundant. There appears to be a definite relationship between this abundance and the drawing of the wind up these miniature canyons. It is quite possible and even probable that further survey along the St. Croix will disclose the presence of the rust in other localities in that vicinity.

POSSIBLE SOURCES OF MINNESOTA'S INFESTATION.

While it is not possible at this date to state definitely the actual source or sources from which Minnesota obtained this disease, beyond, of course, the one introduction of diseased trees by Nursery A in the spring of 1915, certain facts point most strongly to the probability of its coming from Wisconsin. We know that diseased trees were brought to St. Croix Falls in 1908 or 1909, or in both years. It was a portion of these trees planted at Lake Waupagasset, Polk County, Wisconsin, which first called our attention to the presence of the rust so near our eastern border, and which this year (and previously?) infested a large area in the neighborhood of the above mentioned lake near the St. Croix.

The owner of Nursery B below Stillwater, in which the disease has probably been present for more than one year, claims that he has bought only seed from European sources, and that his pines for the past ten years have been of his own raising. The row of eighteen-year-old trees, upon which the blister rust was first found in that locality, was planted there when the nursery was first established fourteen or sixteen years ago, and so far, those in a position to know where the trees came from have claimed inability to state the source. The owner of Nursery A at Taylors Falls, as has already been stated, unwittingly brought some diseased trees from Wisconsin to his nursery in the spring of 1915. So far inspections of all other nurseries in this state have failed to disclose the rust.

These facts, and the further fact that we have only found the disease centers thus far along the St. Croix, in no case hardly more than two miles from the river and for the most part close to the river, points strongly to its introduction into this state from Wisconsin, and manifestly whatever we may do in Minnesota towards its eradication (and it is not assuming to state that all has been done that could be done this summer with the time and money at our disposal) will be futile, unless Wisconsin authorities feel the gravity of the situation and do their part in that state.

Both infestations at Dry Creek and Pine Hollow Creek, as well as that at Nursery B, have been discovered by experts in the Nursery Inspection Force, employed by the State Entomologist to scout along the St. Croix, covering the Minnesota side from the upper dam about twelve miles above Taylors Falls to Stillwater and below.

Wisconsin, to date, has made practically no similar survey of its side of the river, but has been content to give attention to eradication of pines, currants and gooseberries about Lake Waupagasset and to scouting in the region close to St. Croix Falls. On June 10th the Wisconsin Entomologist issued a quarantine notice, forbidding the entrance into that state of any five-leafed pine.

LIFE HISTORY OF THE WHITE PINE BLISTER RUST.

As above intimated this parasitic disease cannot pass from pine to pine, but must go to currant or gooseberry and back to pine. It can, however, pass from currant to currant or currant to gooseberry, both species in the genus *Ribes,* or from gooseberry to gooseberry. It is transmitted from one host to another by means of tiny spores very much smaller than grains of pine pollen (a spore being hardly visible to the naked eye), which can be borne it is believed many miles by the wind. It occurs to us that other agencies which may aid in its

Fig. 1. On left: Branch showing fruiting of current year, and evidences of previous year's fruiting. Note the white membrane (blister) pushing out through swelling in bark. Courtesy of R. G. Pierce, Bureau of Plant Industry, U. S. Dep. of Agr. On right: Specimen of lower branch of *P. flexilis* nine years old, three feet high. Has evidently fruited at least once in previous years. Nursery B, July 28, 1916. Original.

dispersal are found in birds, various insects, cattle and other quadrupeds, as well as man himself.

During May (perhaps also in April) June and early July in Minnesota open and closed blisters may be seen on twigs or large branches or even on trunks of five-leaf pines. The presence of these blisters, white just before opening and about one-quarter inch across, and more or less elliptical in shape, is accompanied by a swollen, unnatural appearance of the bark of the tree on the affected portion. Blisters, which have opened, disclose the yellowish or orange spores (peridermium spores) within. These after a few weeks are disseminated, those reaching the leaves of currants and gooseberries starting upon the under side of the leaves, if the weather is not too dry the second stage in the life history of the fungus, attacking the leaves by sending tiny root-like processes into the living tissue and later developing very small yellow masses of spores on the under side. These spores are called uredospores; they are spread by the wind and probably by some of the other agencies mentioned above, infesting other leaves upon the same bush or upon other bushes. This form of reproduction continues during a large part of the summer, and in this way the disease may spread long distances if currants or gooseberries, wild or cultivated, are abundant. During June and July one finds present uredospores. Late in July (July 22nd was our first date at Dry Creek) another stage is found upon the leaves of affected *Ribes*. The spores in this latter stage are present until Autumn, being known as "teliospores." These cannot reinfect currants or gooseberries, but must go to the bark of pines in order to continue the life of the parasite. As before stated, the disease may remain dormant, or at least not visible on pine for from

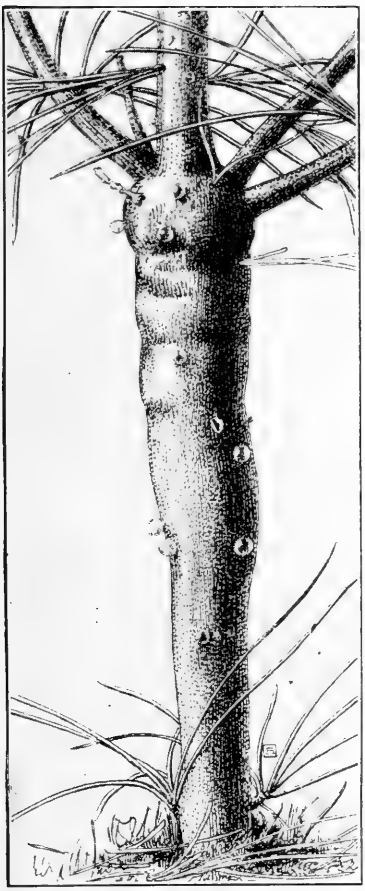


Fig. 2. Young white pine showing swelling and pycnidial drops of liquid caused by blister rust. Bureau of Plant Industry, U. S. Dep. of Agr.

two to six years, or possibly longer, hence, its occurrence in any state is no reflection upon the work of inspection officials or plant pathologists. The bodies producing teliospores looking like tiny threads less than one-quarter inch long, grow in clusters on the underside of the leaf and are easily visible with a lense. A tree attacked by these spores after a time exhibits a swelling of the bark at the diseased portion, generally losing its natural green color. Very early in the spring, and frequently at other seasons a clear liquid exudes in drops from this discolored bark. This liquid contains microscopic spores known as "pycnospores," the function of which is not readily understood. The appearance of these drops generally precede the appearance of the blisters.

After the peridermium spores are discharged from the blisters on the pines, said blisters remain as open cavities and the bark in the vicinity dies, exhibiting later a cracked and discolored appearance and showing evidence of a cancerous growth. The region about the blister may in fact exhibit "canker" of some sort during the period of spore discharge or before. This was clearly evident in the case of our first finding in Nursery B. If the tree is not killed immediately by the attack, and a large tree may not be, it may give off spores every year thereafter to infect currants and gooseberries in the vicinity. It is not known that spores live over winter on currant and gooseberry; so far most of the evidence would indicate the contrary. It has been generally supposed that if all currants and gooseberries within a radius of 1,500 feet from an infested pine or pines were destroyed, the danger of the infection spreading would be eliminated, but this year's observations indicate that this is possibly an unsafe assertion.

The life history of this parasitic fungus has been given very briefly, but we believe sufficient data have been presented to make it clear what a difficult problem is before us, if we wish to eradicate it in Minnesota, and how impossible the solution of this problem is unless neighboring states offer efficient co-operation for their own protection, as well as for the protection of this state.

WORK DURING THE SUMMER AND AUTUMN OF 1916.

Immediately upon the discovery of the rust in the two nurseries above referred to, the State Entomologist, by the authority invested in his office, imposed a quarantine forbidding the sale and shipment of any five-leaf pines, currants and gooseberries from either of the above nurseries until the rust had been eradicated therefrom. Acting upon the advice of the Division of Plant Pathology of the Experiment Station and the Entomologist, owners of these nurseries voluntarily destroyed all pines known by them or suspected by them to be infected,

and all currants and gooseberries upon the premises, whether infested or not, and whether occurring within the so-called 1,500-foot limit or outside of it. In Nursery B, where infested currants were found in addition to the affected pines originally discovered and 75 feet from the latter, the Entomologist's deputy continued to find infested branches on young pines in different blocks, exhibiting fruiting areas of this or previous years. Since danger of infestation from these pines in the present season was over at the date of the discovery, the blocks of pines containing same were left for destruction later. The names and addresses of all consignees receiving pines for the past six years, with size and variety of pine, were secured from the proprietors of these nurseries. These were designated as "leads," and most of them were followed either by the Entomologist himself or a deputy, or by employees of the Plant Pathology Division or of the Federal Bureau. The remainder will be handled next spring if any money is available for this work. When one understands that some of these leads, containing many trees, might take one to a nursery, from which, in turn, many of the same trees had been again sold, requiring further search, it will be realized that the task is not a small one. Suspected trees found by following these leads were destroyed by the owners, or by deputies with the owner's consent. Nurseries A and B were both plotted, and location and numbers of all five-leafed pines, gooseberries and currants were shown on maps.

A systematic inspection of all nurseries carrying pine was started early in the season, attention also being given in June, July and later to currants and gooseberries, as well as pines. No evidence of White Pine Blister Rust was found in other than the two nurseries mentioned. This inspection was quite apart from the regular annual inspection, which latter, this year, has been somewhat delayed on account of this emergency work. On July 7th the quarantine was raised from Nursery A, it having been shown to our satisfaction that all evidences of the disease, both on pines and Ribes had been eliminated from the nursery; all pines, currants and gooseberries upon the place having been burned.

The first conference upon the White Pine Blister Rust of Experiment Station authorities was held in Dean Woods' office, March 2d. At this conference representatives of the Minnesota Forestry Board, the Minnesota Forest Service, the Division of Horticulture and of Plant Pathology, the College of Forestry, and the State Nursery and Orchard Inspection Service were present. It was then unanimously resolved to strongly urge the Federal Horticultural Board to place a quarantine on shipments of five-leaf pines and Ribes from those states, known to be infested with White Pine Blister Rust. The conference

further decided to send letters to all Minnesota representatives, as well as to the Secretary of Agriculture and the U. S. Forest Service, stating that we heartily approved the attempt of the Federal Horticultural Board to eradicate the White Pine Blister Rust, and urging the importance of passing H. R. No. 9802, if action had not already been taken.

Similar conferences were held at intervals during the summer. On June 20th, realizing that we were confronted with an emergency that we could not meet with the funds normally at our disposal, a committee consisting of Dean Woods, Dr. Freeman, State Forester

Fig. 3. A portion of our white pine blister camp on the St. Croix. Pines are more numerous in the locality than the picture indicates. Bartelt photo.

Cox, R. G. Pierce of the U. S. Bureau of Plant Industry, and the State Entomologist, appeared before your Excellency, stating the existing conditions and asked for an emergency appropriation of $1,000.00 for the use of the Entomologist to enable us to carry on the work of survey and eradication. This request was granted by yourself and the other authorized officials. Your committee's resolutions at the time contained an intimation that if necessary more funds would be made available. The resolutions, which are here given in full, contained also the opinion of the committee that owners of trees and shrubs (nursery owners particularly referred to) who lose same thru necessary destruction should be reimbursed upon the basis of a proper appraisement of their value by a committee appointed for the purpose.

This referred only to stock not known to be diseased. At a meeting of our leading nurserymen with station authorities and later by a resolution of the Board of Directors of the State Horticultural Society, it was determined that such a committee should consist of a practical, conservative nurseryman, a representative of the Horticultural Division of the State Experiment Station, and the nurserymen who suffered said losses. Mr. John F. Andrews of Faribault and Professor Leroy Cady were chosen to act with the third party as above indicated in each case.

RESOLUTIONS PASSED IN GOVERNOR'S OFFICE, JUNE 20, 1916.

Whereas, the State Inspector of Nurseries has found a most dangerous plant disease taking root in Minnesota and that it must be immediately eradicated, and has for the purpose of work tending to eradicate said disease asked for the authority to incur not to exceed one thousand dollars ($1,000) expense prior to August 1, 1916;

Now, therefore, be it resolved, that it is hereby declared that the situation so reported by the State Inspector of Nurseries is a calamity, and we do hereby consent to the incurring of all necessary expenses by the said State Inspector of Nurseries in combatting and eradicating said disease, known as "white pine blister," to an amount not to exceed one thousand dollars ($1,000).

Resolved, further, that it is the sense of the undersigned officers of the State of Minnesota that, in harmony with an appraisement by a proper committee, the Legislature convening in the winter of 1916-17 be urged to properly compensate nurserymen and others who lose stock through its destruction for the purpose of stopping this calamity.

June 20, 1916.

(Signed)

J. A. A. BURNQUIST,
Governor.

J. A. O. PREUS,
Auditor.

A. C. GOODING,
Treasurer.

The Entomologist was fortunate in securing in the early part of the season the services of two good workers, Dr. Reynolds, Plant Pathologist, assistant Professor of Botany of North Dakota Agricultural College, and Professor Jensen, formerly a student in our own University and later a graduate student of Cornell. The discovery of the infestation at Dry Creek has already been mentioned and eradication work was instituted here with Mr. Rose and Mr. Badger having under them a force of laborers. These two men and laborers were part of the time on the payroll of the State Entomologist, and at other times on the federal payroll. Teliospores were found here for the first time on July 22d. While this eradication work was taking place at Dry Creek, a camp having been established there to facilitate the work, a survey of the river for twelve miles above Taylors Falls as far as the

Upper Dam was being conducted by Messrs. Reynolds and Jensen without discovering further infestation. This survey was conducted to and below Franconia. Later Mr. Harry Bartelt had charge of this camp, and did most effective work, outlining with accuracy, we believe, the boundaries of the infested area and supervising the eradication. Meanwhile, Mr. Maynard H. Coe, another employee of the State Entomologist having finished the work of supervising the destruction of stock and inspection of Nursery B, started a survey of the St. Croix below Stillwater as far up as Franconia. Thus, a complete survey of the Minnesota side was made from a point below Stillwater to Taylors

Fig. 4. Work of eradication. The four men in the background are equidistant from each other, each man ranging slightly behind the man on his right, and the right hand man following the (blazed) line. The party in the rear is checking up the work. Bartelt photo.

Falls, and twelve miles above. Mr. Coe was later joined by Mr. Salmon, a temporary assistant of the U. S. Bureau of Plant Industry, and these men on September 25th discovered quite a large infested area at Pine Hollow Creek (in region known as Cedar Point), three miles below Osceola.

On September 5th your committee voted to allow the State Entomologist $300.00 additional upon his representation that further expense was necessary in order to eradicate all infested Ribes before frost. Had it not been for your cordial co-operation in this way, both on June 20th and September 5th, we would have been unable for financial reasons to co-operate effectively in this survey and eradication work.

About October 5th all field work stopped, heavy frosts causing the leaves on currants and gooseberries to fall.

Weekly reports have been filed in the Entomologist's office by the field men and the writer or his deputy, or both, were frequently in the

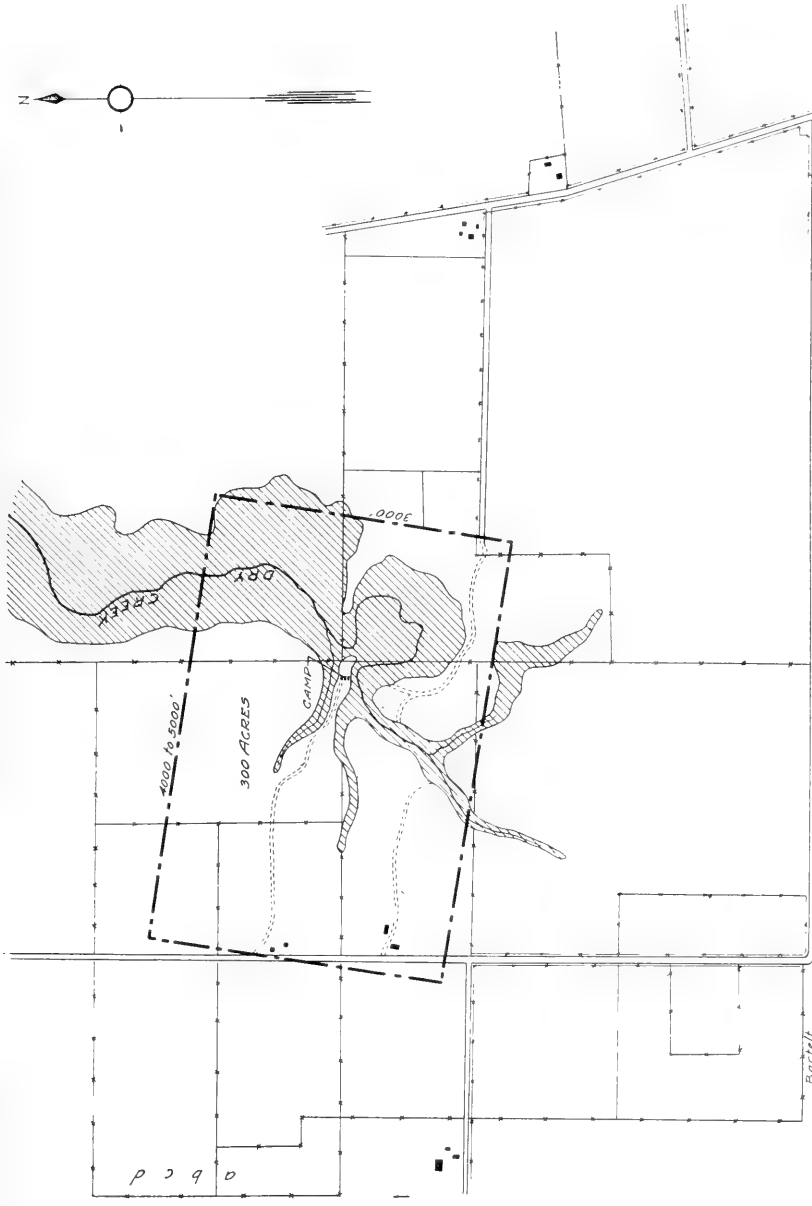


Fig. 5. Outline map of Dry Creek region. The rectangle bounded by heavy lines includes an area of approximately 300 acres. The side lines are about 1,500 feet on either side of the infection center as first found. The crosses on property boundary lines indicate extent of scouting activities. Late in the season infested Ribes were found in considerable abundance at a, b, c, d, a point far west of the infected center as originally located. Bartelt.

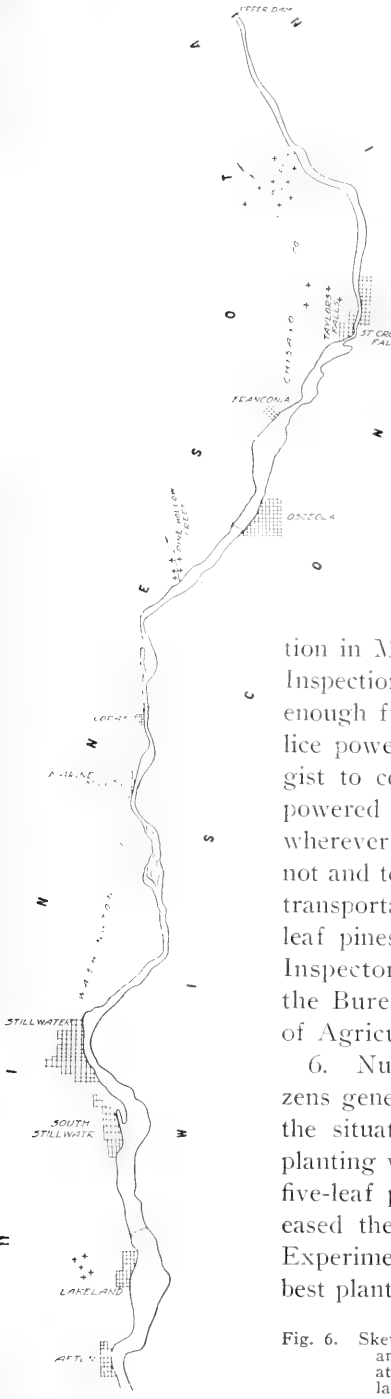
field. In getting to Taylors Falls and camp and return, as well as to the infested area at Lakeland and Pine Hollow Creek, the use of an automobile was found most advantageous.

It must not be concluded from the findings of the men this year that infestation does not exist in other localities on the St. Croix, for the hosts of currants and gooseberries along the river make it easily possible for infestation to be overlooked. Faithful survey work in this region for several years is necessary.

In eradication work the plan which appeared to give the best results consisted in running parallel lines thru the infested area some feet apart, said lines indicated by blazes or other marks. In these narrow lanes workmen uprooted all Ribes, placing the plants in piles for burning. Their work was closely followed by those in charge in an effort to see that no plant was overlooked. In a survey also to determine boundaries of an infested area the same general plans were followed, the lanes being wider. In this feature of the work the bushes were placed in piles by the workmen and then carefully examined by experts in charge. The evident limits of an infested area being found (Dry Creek Camp referred to), a "quarantine" area was outlined, including the infected area and nearly or quite 1,500 feet beyond the limits of infestation as found. At Dry Creek this included over 300 acres and it was over this acreage that the men attempted most faithfully to exterminate Ribes. Later the disease in this locality was found far outside of the area referred to.

SUMMARY AND FUTURE OUTLOOK.

1. White Pine Blister Rust is present in Minnesota, and has been found near our eastern boundary on pine and species of the genus Ribes. There have been discovered four points of infestation along the St. Croix River. Possibly, and probably, another year's survey will disclose other infested localities in the same region, i. e., along the river. One of the above "centers" is accounted for absolutely, diseased trees having been brought in from Wisconsin. With the exception of one or two leads from Nursery A (trees destroyed before blisters appeared) this rust has not been found in this state west of the Mississippi River. A careful inspection this year failed to disclose it in any Minnesota nursery, excepting Nursery A, and Nursery B (see above). It is to be noted that since it may not appear on the surface of a pine for some years after infection, it may be present on trees introduced directly or indirectly from Europe, or from some infected nursery in the United States, and owners of said trees be unaware of its presence.



2. From evidence at our command it would appear that these infestations came from Wisconsin (in the case of Nursery A this is an established fact).

3. Our state forest service estimates that there is approximately twenty-five billion feet of merchantable white pine standing in Minnesota, worth about twenty-five millions of dollars. Thousands of young white pine trees are annually planted in an effort to reforest our denuded timber lands. Is Minnesota willing to allow this menace to go unchecked?

4. The tardy development of this disease in pines makes the proposition of eradication a difficult one, calling for survey and inspection year after year for a long period.

5. As far as inspection and eradication in Minnesota nurseries is concerned, the State Inspection Service can handle the work, provided enough funds are available, but more extensive police power should be granted the State Entomologist to cover this emergency. He should be empowered to destroy all suspected trees and bushes wherever found whether the disease is apparent or not and to prohibit the entrance into Minnesota and transportation within this state of any of the five-leaf pines. This additional police power of State Inspectors is urged in a recent bulletin issued by the Bureau of Plant Industry, U. S. Department of Agriculture.

6. Nurserymen, Park Commissioners, and citizens generally should appreciate the seriousness of the situation and should refrain from buying or planting white pine for a number of years. If any five-leaf pines on their premises appear to be diseased they should communicate at once with the Experiment Station. Currants and gooseberries are best planted at a distance from five-leaf pines.

Fig. 6. Sketch of St. Croix River from Afton to the upper dam, the area covered by our survey on Minnesota side. Crosses at Dry Creek, Taylors Falls, Pine Hollow Creek and Lakeland mark the four affected localities found this summer.

7. In addition to nursery work, there should be a state wide survey of Minnesota to learn whether this disease occurs in sections other than those examined this year.

8. Any work towards eradication in Minnesota is futile unless Wisconsin, in which state the disease is known to exist, co-operates by continuous and efficient efforts at eradication within her own boundaries. This statement is also applicable to any other adjacent state in which the disease occurs.

9. Purchasers of stock from nurseries should realize that an Inspector's certificate is not a guarantee that pines in that nursery are free from White Pine Blister Rust, since as previously explained the disease may be present in the tissues of trees and not be apparent upon the surface.

10. *The relation of Nurserymen to the Federal Horticultural Board in connection with this disease.*

The Federal Horticultural Board in a commendable effort to save the five-leaf pines in the large area west of the Continental Divide have asked (not required, be it noted) nurserymen in Minnesota with those of many other states, not to ship pines, currants or gooseberries west of the Dakotas, and broadly speaking west of a line drawn south from those states. As State Inspector and collaborator with the Federal Board, the writer urges nurserymen to heed the suggestion coming from Washington, but expresses the hope that this request on the part of the Board may be modified. While the Board has prevented the introduction of five-leaf pines from Europe, it has placed no quarantine upon pines being shipped from the five or more states in the east known to be infested. Further, there is no restriction at present upon the entrance of currants and gooseberries into the United States from Europe. This unrestricted entrance of currants and gooseberries is probably permitted because so far practically all of the evidence as to spores being carried over on dormant bushes is negative. Such being the case and with the above facts before us, it would appear that dormant currants and gooseberries might be shipped with safety into the states, or portions of states lying east of the Divide, Eastern Montana, for example.

Personally, we should like to see all foreign importations of nursery and ornamental stock into the United States prohibited for a number of years. The White Pine Blister Rust was introduced and distributed before our citizens were aware of its presence. Other diseases as bad or worse might be brought in at any time, to develop later and cause thousands of dollars worth of damage. In this connection we quote from a letter received from J. G. Sanders, formerly State

Entomologist of Wisconsin, and now Economic Zoologist of Pennsylvania. The letter is dated October 23, 1916.

"A short time ago I attended a gathering of State Inspectors of New England, New York and Pennsylvania at Fall River, Mass., where I went into the field and observed the work of the blister rust after about eight or nine years' standing. The destructive possibilities of the blister rust are truly amazing in these districts, where we found white pines five inches in diameter completely girdled, and branches up to twelve feet in length on old thirty- to forty-foot pines completely destroyed."

11. A conference to consider the necessary measures for the suppression of the White Pine Blister Rust in Minnesota and Wisconsin was called in Dean Woods' office October 28.

There were present: Dr. Haven Metcalf, head of office of Forest Pathology, Bureau of Plant Industry, U. S. Department of Agriculture; Dr. E. D. Ball, of the Wisconsin Nursery Inspection Service; Dean A. F. Woods; Dr. E. M. Freeman; Professor F. L. Washburn; Mr. D. P. Tierney, of the Minnesota Forest Service, and Professor E. G. Cheyney.

There were represented: The U. S. Department of Agriculture; the Nursery Inspection Service of Wisconsin; the University and Nursery Inspection Service of Minnesota, the Minnesota State Forestry Service and the Forestry Association. After an exhaustive discussion of the subject, all those present subscribed to the following resolution:

Whereas, the white pine blister rust is a menace to our native white pine; and,

Whereas, the disease is known to be present in Minnesota and Wisconsin; and,

Whereas, the spread of this disease means the destruction of all future growth of white pine in these states; and,

Whereas, the definite location of these infections is not known; therefore,

Be it resolved, that the legislatures of Wisconsin and Minnesota be requested to make an adequate appropriation each year of the coming biennium for the purpose of scouting out the infection with a view to working out the best remedial measures.

For the next biennium, if the people of Minnesota desire the state to make an effort to eradicate this most destructive disease, men and money are necessary. The exact program and expense involved will have to be determined by a conference of officials and experts interested. It is safe to assume that an efficient survey and campaign of eradication will call for the expenditure of a large sum of money.

ACKNOWLEDGMENTS.

I take pleasure in expressing our appreciation of your co-operation, and at the same time that of the State Treasurer and State Auditor, which has enabled us to accomplish much more than would have been possible otherwise. We owe much to the co-operation of the U. S.

Department of Agriculture. The state is also indebted to Director A. F. Woods of the Experiment Station, who has done all that he could to urge the work to a successful end. To Dr. Freeman's council and advice as Plant Pathologist, we are also much indebted. A large part of the satisfaction felt at the end of the season has been due to the untiring efforts and interest shown on the part of George W. Peake, Deputy Nursery Inspector, who has not spared himself in directive work in the field. The specialists taking part in survey and eradication work have been mentioned in other parts of this report. We are particularly indebted to the Appraisement Committee, Messrs. Cady and Andrews, whose task has not been an easy one. Mr. Grover Conzet, formerly with the Minnesota Forest Service, has estimated for us the market value of the white pines at Dry Creek, and the Forest Service has borne a small share of the expense. The original drawing in this report was made by Miss Helen A. Sanborn.

FINANCIAL STATEMENT.

In addition to the two emergency appropriations of $1,000 and $300 respectively for the summer's work, it has been necessary to use over $1,000 of the State Entomologist's appropriation, which would normally go to regular inspection work; or to be exact, $1,026.72. In addition to this the Federal Government has co-operated thru the Bureau of Plant Industry to the extent of about $1,200.00.

WHITE PINE BLISTER RUST EMERGENCY FUND EXPENDITURES.

Emergency Appropriation, June 20, 1916		$1,000.00
Emergency Appropriation, September 5, 1916		300.00
		$1,300.00
Telegrams (to Federal Horticultural Board, etc.)	$9.29	
Salaries: Experts and Laborers (Reynolds, Jensen, Rose, Badger, Coe, Rafter and Booton)	681 01	
Circulars of Information and Colored Plates of White Pine Blister Rust for distribution	125.20	
Expense: White Pine Blister Camp, traveling and miscl.	454 82	
Mileage	29.68	
		$1,300.00

In addition to the above:

Money expended from State Entomologist's Fund $1,026.72
Money expended by Bureau of Plant Industry, approximately 1,200.00
Small sums also from the Division of Plant Pathology of the State Experimental Station, and from the Minnesota Forest Service.

Respectfully submitted,

F. L. WASHBURN,
State Entomologist.

FIG. 7. MAP SHOWING INFESTATIONS OF WHITE PINE BLISTER RUST, AS FAR AS KNOWN IN 1916, IN THE UNITED STATES.

(Adapted from a New York State Circular)

EXPL. OF PLATE: Black triangles denote infestations of pines, circles those of currants or gooseberries. Shaded belt indicates limits of Eastern White Pine growth as far as included in mapped area. Black circles in darker shaded portions indicate areas of heavily infected currants and gooseberries. Dotted areas indicate centers of infection where principal efforts were made to eradicate diseased plants.

REPORT ON NURSERY AND ORCHARD INSPECTION AND INSPECTION OF FOREIGN STOCK FOR THE YEARS 1915-1916

F. L. WASHBURN

(Work of 1915, Circular 37, Feb. 1, 1916.)

The work of inspection has increased materially each year in Minnesota and the nursery business is becoming more and more an important asset in this state. We can urge the citizens of Minnesota, in view of the splendid stock and large assortment of hardy fruit trees and shade trees carried by the nurserymen, to plant Minnesota-grown stock as far as possible. The nurserymen appear to appreciate the necessity of combating crown gall on raspberries, and, as a result of their efforts, we find crown gall on raspberries less abundant than in previous years, though still an important enemy to raspberry growing.

In traveling about the state last summer, the Entomologist was struck by the lack of orchards in the central part. There are hundreds of acres of land between Long Prairie and Wadena and north of Park Rapids containing but few fruit trees. In a hurried trip through this section, miles of what would seem to be desirable orchard land were passed between Brainerd, Little Falls, and St. Cloud, with not a fruit tree showing. The Swan River Valley also, where but few fruit trees were seen, should have its gentle slopes and hillsides dotted with orchards.

The wet weather last spring and early summer caused a remarkable growth of weeds in nurseries, and the wet ground made it difficult to eradicate these, but nevertheless, the nurseries are in quite good condition throughout the state. The season was favorable for extensive growth of all nursery stock.

In order to permit private citizens to ship a few trees or shrubbery or plants to friends, or perhaps from the country to their own places in the city, we have inauguated a system of permits, that the law may be complied with. It is only necessary for a citizen to send the name and address of both consignor and consignee, the number of packages and variety of stock each contains, and the probable date of shipment and we issue a permit which takes the place of the nurserymen's shipping tag, and is accepted as such by the express or freight agent or postmaster. A record is kept of

parties receiving permits and the numbers of same and if it is evident, from the number of these records that a business of some magnitude is being transacted by any party, without proper inspection of stock, issuance of permits to that party ceases, with a suggestion that they conform to the law and obtain a regular certificate. In other words, these permits are not intended for use in the nursery trade.

Christmas trees shipped into our cities from wooded sections are of course exempt from the rules of our inspection laws. Deprived of their roots, they could in no way be regarded as nursery stock nor would they in that condition come under the designation of forest trees—the latter being subject to the regulations of the Inspection Service. Express and freight agents should govern themselves accordingly.

The presence of crown gall on raspberry or blackberry plants disqualifies a nurseryman from receiving a certificate until the affected block or blocks of plants are destroyed. The presence of the hairy root form of crown gall on apple would also disqualify if observed. The presence on apples of a large amount of crown gall in the "hard gall" form would, when found, call for a request from the inspector that the nurseryman eliminate such stock, for business interest if for no other reason. At the same time, while pointing out to nurserymen the infectious character of the disease, in view of the fact not only observed by the inspector but also claimed again and again by practical growers, that in Minnesota, trees affected with the "hard gall" form of the disease, are not seriously impaired as to growth and bearing qualities, the Minnesota inspector does not disqualify a nurseryman if a moderate amount of this disease is found in the nursery. Nevertheless, the fact that these trees so affected are rejected by law in many states (and in fact this form of the disease may be destructive to trees in other latitudes and in other soils) is emphasized so strongly by the Minnesota inspection force that nurserymen need no further stimulus to eradicate it as far as possible when found.

If our appropriation would permit, a winter inspection of apple and cane stock while in the cellar, would be helpful in this connection.

We have inspected 120 nurseries this year, of which nurseries 115 have received certificates, the remaining four not having as yet paid the legal fee and therefore not having as yet been so favored; also dealers' certificates have been granted to eight dealers. Collections have been made to the amount of $625, which has been turned in to the State Treasury and receipt received for same.

Fig. 8. Teams starting to work in one of the larger Nurseries

IMPORTED STOCK.

In the matter of imported stock, it is surprising to note that in spite of the war, and all that it means to Belgium, the importations of azaleas this fall (1915) have been nearly as extensive as in years previous to 1914. The azaleas arriving from Belgium in large numbers have reached Minnesota in excellent condition, showing every evidence of care in cultivation, digging, and packing. Cases of imported stock, including azaleas and ornamentals, to the number of 594 boxes, have been inspected to date, representing approximately 518,330 plants.

The allies have placed a very effectual stopper on importations from Germany, the Belgian and we believe also the Holland dealers having to make affidavit that the stock to be shipped via the English channel has been grown in one or the other of these two countries.

Further, the amount in cash for which each azalea shipment is sold has to be deposited in an English bank to remain there until after the war. Quoting from a statement in "American Fruits," when this is done, a "permit may be issued allowing free passage for such shipment. According to a letter from a Dutch firm of growers, after this became known, the Belgian Exporters' Association was notified by the German authorities, who have possession of that part of Belgium where these plants are grown, that in the circumstances export would not be allowed." Yet, in spite of this prohibitive decree, Minnesota has been receiving large consignments from Belgium as above noted. The 594 cases above mentioned came from the following countries: From Belgium, 218 cases; from Holland, 279; from France, 65; Japan, 22; Germany, 5; England, 5.

We find that stock coming from Holland is, almost without exception, free from insect pests and beautifully packed. This is also true of azaleas shipped from Belgium. These latter plants reach us in such fine shape and so free from insect pests that we have adopted the plan of allowing the importer to unpack shipments, keeping them together, and preserving all tags, records, and numbers on boxes (burning packing), pending the arrival of the inspector. This saves us additional trips to a distant locality to examine small consignments arriving later than the main part of the shipment.

Inspections of Imported Plants.

Dec. 1, 1914, to Sept. 1, 1915.

Number of plants		502,180
Number of cases—		
From Belgium	53	
From Holland	234	
From France	65	
From Japan	22	
From Germany	5	
From England	4	
	— 383	

Sept. 1, 1915, to Dec. 1, 1915.

Number of plants		28,150
Number of cases—		
From Belgium	181	
From Holland	73	
From England	1	
	— 255	
Total number of cases	638	
Total number of plants		530,000
Total number of cases from Belgium		234
Total number of cases from Holland		307
Total number of cases from France		65
Total number of cases from Japan		22
Total number of cases from Germany		5
Total number of cases from England		5
Total cases		638

The inspection service works in co-operation with the Federal Horticultural Board, receiving from Washington the notice of all shipments of nursery stock from abroad and being advised of all quarantine measures imposed by the Government.

The White Pine Blister Rust.

This disease, found on pines and, in one stage, on species of Ribes (currant and gooseberry), has become such a menace to our forest interests that not only has the Federal Horticultural Board forbidden the entry of all pines into this country from Europe, but is also considering a quarantine of areas in the United States already infested. This is a matter calling for the closest co-operation between the Plant Pathologists, the Forest Service, and the Nursery and Orchard Inspection Services in the various states, particularly in those states where lumber interests are represented.

For four years we have been watching a planting of imported pines in a Minnesota nursery and, up to date, have not observed the appearance of this disease. Nevertheless, we plan for the coming season a careful survey of all nursery stands of species of pines

Fig. 9. Part of a field of 500,000 2-year-old Apple Trees

as well as those of currants and gooseberries, besides a checking up of all shipments of these forms into Minnesota, and far as possible, their ultimate distribution therein. To do this properly, generous co-operation upon the part of the Plant Pathology Division of the Experiment Station will be necessary.

At a recent conference (March 2, while this report was with the printers) of representatives of the Minnesota Forestry Board, the Minnesota Forest Service, the College of Forestry, the Minnesota State Forestry Association, the Horticultural and Plant Pathology Divisions of the Minnesota Experiment Station, and the Minnesota Nursery Inspector, a resolution was unanimously passed to the effect that we strongly urge the Federal Quarantine Board to quarantine those areas (as regards shipment of pines and Ribes) which are known to be infested with white pine blister rust, and the Secretary of the Conference was also instructed to write to the Minnesota senators and representatives, urging them to act favorably upon H. R. 9802, introduced by Mr. Wason.

Since large consignments of pines, currants, and gooseberries have probably been received from infected areas, by large nurseries in the United States, nurserymen and other importers are urged to avoid placing orders for pines or currants or gooseberries at the present time with wholesale dealers. In this connection it may be stated that a quarantine is just about to be issued by the Federal Horticultural Board, preventing the importation of five-leafed pines, as well as all currants and gooseberries from Canada and Newfoundland. This disease is very slow to appear on plantings of pine. Its first appearance dates possibly three years after the pines are set out, in this climate, although it might not appear until considerably later. It is recognized by yellow spots on the bark of the pine with irregular white edges, first appearing as irregular swellings or blisters, which swellings or blisters later break open. The yellow color is caused by the presence of the powdery-like, yellow spores. On currants and gooseberries, it is observed in the form of very small, yellowish powdery masses on the under side of the leaves about the size of the head of a pin. It must not be confounded with the other yellow spores seen commonly on our gooseberries, the patches of which are much larger.

Any nurseryman, observing anything at all suspicious upon his pines, should at once report the fact to the Inspection Service. It would be well to advise this office of any plantings of European pines in one's nursery occurring at any time within the past eight or ten years.

The Entomologist publishes, at intervals during the year, a "News Letter," mailing to all nurserymen, dealers, and florists on our lists. This publication contains items of common interest to nurserymen, florists, and the Nursery Inspection force.

It is to be noted that the above statements regarding White Pine Blister Rust were printed Feb. 1, 1916. Since that date there have been important developments and much work accomplished in this connection. See page 10.

The Minnesota Inspection Service feels hardly justified in taking a parental attitude toward our nurserymen similar to what is found to prevail occasionally in some states. In other words, the State Entomologist does not feel authorized either to criticize business methods on the part of his nurserymen constituents, or to pass upon business relations existing between nurserymen and their patrons. A most cordial and friendly feeling exists between the inspector and inspected in Minnesota, and in the light of this friendship, we may repeat to a nurseryman privately a criticism upon stock sold, made to us, if such action upon our part is likely to prevent a repetition which may injure the nurseryman himself. We have also, upon rare occasions, upheld patrons in their claim that satisfactory stock had not been furnished. On the other hand, we do not feel that it lies within the power of the Entomologist to interfere with or restrain trade by commenting to any purchaser of nursery stock, upon prices paid or claims made as to value of stock furnished. Whatever personal views the inspector may have, he carefully refrains from voicing, believing that to be the most desirable and really the only position to take in his official capacity. A diseased or insect-infested tree or shrub furnished a patron would of course bring upon the nurseryman selling the same the private criticism of the inspector and an admonition.

Nursery inspection in this state at present is in an educational stage. It serves as a check upon the introduction and spread of injurious insects and plant diseases, but it does more than that in that it compels attention to pests and diseases hitherto not understood or even noticed. Since it is educational and co-operative with University departments, it would seem unwise to separate it from the University at this time and place it under state control, apart from the University, unless a group of allied subjects sufficiently large to dignify it with the name of "Department of Agriculture" be organized for that purpose and precautions taken to guard the work against political interference. Nurserymen appear to be

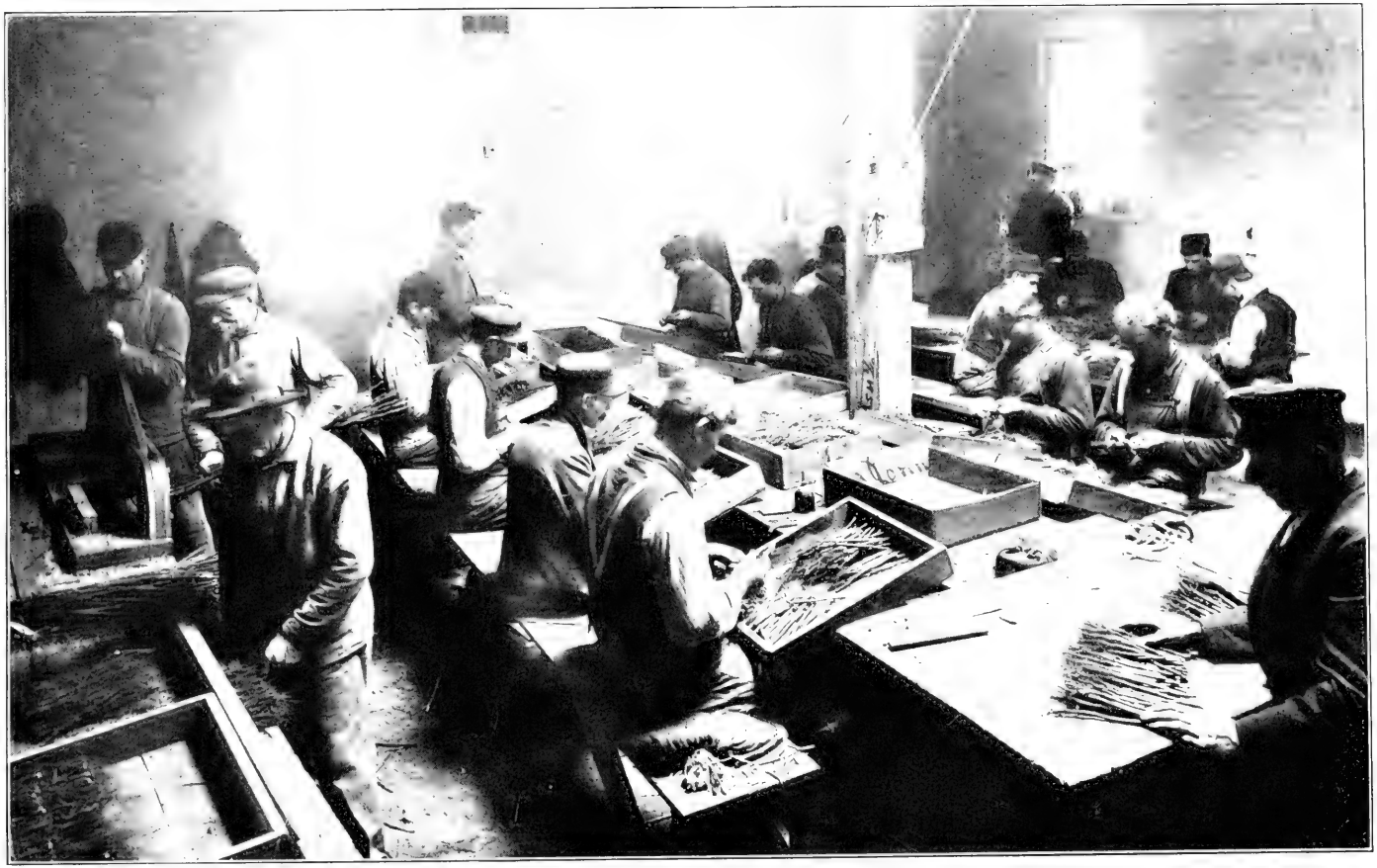


Fig. 10. Making Apple Grafts

universally in favor of the work being retained by the University.

During the spring and summer of 1916, the Inspection Service, in addition to its regular inspection work, plans to begin a survey of orchards in each fruit-growing county in the state to determine whether seriously injurious insects are present, what species are represented, and how serious is the infection. In this connection, it might be mentioned that the English sparrow, when present in an infested locality, has been found to be an active worker in spreading the San Jose scale wherever this scale is abundant; and other birds nesting in the orchards may, in a lesser degree, because of their smaller number, be guilty of the same offense. Orchardists, therefore, desirous of ascertaining whether or not this scale is present, would do well to look in the neighborhood of old birds' nests and in trees or shrubbery which offer favorite perching places for English sparrows. A neglected plum thicket may also harbor this scale.

MINNESOTA INSPECTED NURSERIES.

1915.

All certificates issued in 1915 expire November 1, 1916, thus covering both spring and fall shipments of 1916, and avoiding delays in securing new certificates.

Name of Nursery	Town	Certificate No.
The Albert Lea Nursery C. M. Peterson	Albert Lea	756
The Minnesota State Nursery E. C. Baker	Albert Lea	753
The South Side Nursery Martin Fridholm	Albert Lea	755
The Wedge Nursery Clarence and Robert Wedge	Albert Lea	754
Alexandria Fruit and Poultry Farm W. H. Horton	Alexandria	804
College of Forestry	Arago and Cloquet	810
The Askov Nursery Ludvig Mosback	Askov	708
Austin Nursery C. F. Woodle	Austin	775
Turtle Creek Nursery J. M. Lindsay	Austin	779
Battle Lake Nursery A. A. DeSmidt	Battle Lake	815
Itasca Park Region Nursery L. P. Anderson	Bemidji	808
The Byron Nursery F. E. Cutting	Byron	792
Oslund's Nursery N. N. Oslund	Cambridge	819
Sivert's Nursery Peter Sivert	Canby	741

Fig. 11. A field of Young Evergreens

Fillmore County Nursery ..... Canton 790
G. F. Snyder
The Cokato Berry Farm ..... Cokato 742
A. L. and F. Lee
The North Star Farms ..... Cokato 744
J. W. Beckman
The Wright County Nursery ..... Cokato 743
John Eklof
The Schuster Nursery ..... Crookston 811
Edw. W. Schuster
The Flyen Nursery (Dealers) ..... Dawson 20
Henry Flyen
The Delano Nursery ..... Delano 714
Chas. Sell
The Greysolon Nursery ..... Duluth 709
C. E. Roe
The Eagle Bend Nursery ..... Eagle Bend 802
T. W. Taylor
East Grand Forks Nursery ..... East Grand Forks 805
Oscar Wick
The Brackett Nursery ..... Excelsior 826
A. Brackett
Highlands Fruit Farm ..... Excelsior 821
C. S. Jackson Land Co.
Minnetonka Old Fashioned Flower Garden ... Excelsior 725
Mrs. N. S. Sawyer
The Amber Lake Nursery ..... Fairmont 768
P. C. Christensen
The Commercial Nurseries of Fairmont
(Dealers) ..... Fairmont 26
G. D. McKisson
McKisson's Fairmont Nursery ..... Fairmont 770
G. D. McKisson
The Andrews Nursery ..... Faribault 763
John Andrews
The Brand Nursery ..... Faribault 764
Brand Nursery Co.
The Farmers Seed and Nursery Co. ..... Faribault 765
Wm. Kueker
The Wilwerding Nursery ..... Freeport 813
A. J. Wilwerding
The Mills Lake Nursery ..... Garden City 748
L. D. Mills
The Lake View Nursery ..... Grayling 805
Victor Carlson
Hughart's Sons' Nursery ..... Hamel 711
Hughart's Sons
Howard Lake and Victor Nurseries ..... Howard Lake 740
W. H. Eddy
The Thorp Northwestern Plum Nursery ..... Hubert 706
Freeman Thorp
Jeffers Trial Station ..... Jeffers 732
Dewain Cook
Kenyon Nursery ..... Kenyon 777
J. A. Mogren & Son
The Oak Grove Nursery ..... Kenyon 776
P. H. Volstad
The South Kenyon Nursery ..... Kenyon 778
E. J. Hershaug
The Kerrick Nursery ..... Kerrick 705
Mrs. Margaret Culle

Ayers' Jack Pine Nursery ..... Kimberly 818
H. B. Ayers
The Sunnyside Fruit Farm ..... LaCrescent 788
Frank I. Harris
The Jewell Nursery ..... Lake City 727
Jewell Nursery Co.
The Johnson Nursery (Dealers) ..... Lake City 25
P. G. Johnson
The National Nursery ..... Lake City 728
J. F. Anderson
The Sugar Loaf Valley Nursery ..... Lake City 729
Moseman Bros.
The Tolleson Nursery ..... Lake City 730
G. A. Tolleson
The Mayfield Nurseries ..... Lakeland 767
L. L. May
The Kenyon's Riverside Nurseries ..... Lamberton 734
J. M. Kenyon
The Motter Nursery ..... Lamberton 735
J. P. Motter
The Benson Nursery ..... Lindstrom 785
J. M. Benson
The Chisago Lake Nursery ..... Lindstrom 784
Ludwin Carlson
The Ferguson Nursery ..... Litchfield 737
C. W. Ferguson
The Morrison County Nursery ..... Little Falls 801
Cornelius Kelly & Son
The Daniels Nursery ..... Long Lake 797
Frank Daniels
The Minnetonka Nursery ..... Long Lake 713
Douglas Winter
The Tong Nursery ..... Long Lake 712
George Tong
The Lonsdale Nursery ..... Lonsdale 757
John Vikla
The Luverne Nursery ..... Luverne 747
C. E. Older
The Madison Nursery ..... Madison 749
M. Soholt
H. Allan (Dealer) ..... Mankato 21
The Mankato Nursery ..... Mankato 731
L. Z. Smith
M. M. Sinotte (Dealer) ..... Mankato 24
The Dodge County Nursery ..... Mantorville 781
W. E. Fryer
The Orton Park Nursery ..... Marietta 751
C. J. Orton
The Kidder Nursery ..... Marshall 750
E. D. Kidder
The Minnesota State Nursery ..... Marshall 812
E. C. Eaker
The Deerfield Nursery ..... Medford 758
J. F. Brady
The Medford Nursery ..... Medford 759
G. E. Patten
The Baker Nursery ..... Minneapolis 720
R. F. Baker
The Board of Park Commissioners ..... Minneapolis 722
Theo. Wirth
The Farmer Nursery ..... Minneapolis 803
E. A. Farmer

Fig. 12. A field of 3-year-old Wealthy Apple Trees

The Nicollet & Sibley County Nurseries.....St. Peter 736
C. Edwin Swenson
The Meininger Nursery .....Sherburn 771
L. Meininger
The Minnewaska Nursery .....Starbuck 703
Paul P. Klevann
The Strand Nursery .....Taylor's Falls 783
G. W. Strand
The Tyler Nursery .....Tyler 707
J. P. Ericksen
The Maplehurst Nursery .....Waltham 780
Grace E. Kimball
The Cabinwood Nursery ....Wayzata 799
O. J. Wetherald
The Deephaven Nursery .....Wayzata 715
A. O. Hawkins
The Ferodowill Nurseries .....Wayzata 798
F. X. Ferodowill
The Hawkinson Nursery .....Wayzata 710
Chas. Hawkinson
West Concord Nursery .....West Conford 782
F. J. Cowles
The S. D. Richardson Nursery.....Winnebago 773
S. D. Richardson
The Winnebago Nursery .....Winnebago 772
John Van Blair
The Pfeiffer Nursery .....Winona 786
C. A. Pfeiffer & Son
The University Fruit-Breeding Farm Nursery..Zumbra Heights..... 702
State of Minnesota

NURSERIES IN MINNESOTA NOT HOLDING CERTIFICATE OF INSPECTION FOR 1916.

The Lake View Nursery and Fruit Farm.....Excelsior
P. M. Perry
The Ellison Nursery .....Minneapolis
F. H. Ellison
The Hunter Nursery .....Minneapolis
C. C. Hunter
The Wyse Nursery .....Onamia
Oliver Wyse

We wish to acknowledge helpful assistance from the Plant Pathology Division of the Experiment Station during the year's work.

We have been fortunate in having the services, this year, of Mr. G. W. Peake as Deputy Inspector; we have also had occasion to employ extra help in order to inspect nursery or imported stock. We append, herewith, his report of work for the year just ended:

During the past year, there have been some changes in our methods of orchard and foreign inspection; that is, we are now trying to locate such pests as San Jose scale not only in our nurseries, but in our orchards. Our appropriation does not allow for very much of this work, but during the last season, some little work was accomplished along these lines and the coming season we are planning to extend this work so as to quite thoroughly examine an area of several counties. This work will be reported daily to the office of the State Entomologist where all records will be kept on permanent file. In our foreign inspection, we have found the best of

co-operation in regard to care taken by greenhouse and nursery men. We have asked always that all packing be carefully collected and burned and have met with no opposition to this important ruling. In many cases it is expensive and inconvenient to go to a town out of the Twin Cities for each box of foreign stock shipped in and we have allowed the shipment to be unpacked and packing burned to await the final shipment in that locality or until we had more time for work. So far, we feel this is satisfactory for greenhouses, but of course for nursery stock which comes in the spring, we would not care to try it. Stock from Holland and Belgium and France came in even greater abundance than it has in years past. The imported stock, as a rule, was in very good condition and but few pests—none of any great importance—were found. In several cases we found an abundance of aphids and of oyster shell scale; some few other minor pests which were destroyed by dipping the dormant stock in tobacco solution.

The inspection of foreign stock in the spring of the year was accomplished, for the most part, by the Deputy Inspector, but at certain times, when large shipments of stock arrived at several places at the same time, or an extremely heavy shipment at one place, help was secured from experts in the Divisions of Plant Pathology, Horticulture, and Entomology. Through the courtesy of these men, we were able to keep the inspection work up to date.

During the early part of the summer, an extended trip was taken to trace some few shipments of mountain ash which originally came from Michigan and on which we had evidence of the possibility of San Jose scale being present. In no case was the scale found on these shipments, although many of the trees had died and been destroyed, so it was impossible to determine if scale had been present.

The summer inspection of nurseries was hampered to some extent by the weather conditions in the early part of the season, but although we had about forty more places to visit this year than last year, the summer work was completed so that it did not interfere with the inspection of imported foreign stock which came in this fall. The amount of imported stock from Europe is practically the same this year, but it is coming in very late—in many cases due to slow transportation after it reached the port of New York; that is, on our own railroads.

The coming year, the imported nursery stock to be planted out, of course, will be inspected, as in the past, and the summer work, we hope, will be greatly helped by the fact that provision was made for more extensive field records and collections and closer co-operation with the various sections of the Division of Entomology. During the past year, only one nursery was found with nursery stock infested with San Jose scale. This stock had been imported from New York State and lined out. This nursery now has a modern fumigation house and fumigates all stock leaving the premises, besides thoroughly spraying with concentrated lime sulfur all trees near those which were found to be infested. This was the second nursery in which San Jose scale has been found in the last two seasons and provisions have been made in both cases to see that the scale was destroyed and all stock fumigated before leaving the infested nursery. In both these cases, the stock came from another state and was lined out in the nursery where it was later found. We have been trying to gradually build up the inspection work, so as not only to eliminate the possibility of the spread of pests from nurseries, but also to make a survey from year to year of the various counties in which are found old orchards most likely to be affected with some pest. Because of the fact that Holland stock is so very free from pests and arrives in such first-class condition, and that other states are not inspecting this stock, I should recommend that we do not inspect Holland-grown and inspected stock for greenhouse purposes, but the consignee should be advised to take every precaution to help us keep out the various pests by carefully saving all packing and refuse and burning same; also the boxes if they are made of old lumber; and carefully examining each plant for the brown tail nest or the gypsy moth egg mass. As before stated, we should be advised of the arrival and receive the number of cases and their identification number.

Fig.13. Digging trees with a Power Digger

During the past season, the usual insect pests were in evidence, although the poplar beetle **(Melasoma scripta)** did not do as much damage as in former years, partly due to the seasonal weather conditions and partly due to improved methods of control which some of our nurseries employed.

A pest which has not been in evidence to any extent heretofore (found in nurseries in southern part of state previous to this F. L. W.), but which was very abundant this year, was the woolly aphis which was found on apple, mountain ash, hawthorn, and elm. The oyster shell scale is abundant in some localities, although it has apparently done no great amount of damage where found. It is easily controlled and should be exterminated. Plum and apple aphis were also abundant and the red-humped caterpillar on apple was found several times. The snowball and high bush cranberry in most cases were affected to an extreme extent with green aphis. The raspberry Byturus was, as always, very much in evidence, as were mites and aphids on boxelder. One or two cases of saw fly on blue spruce, both Kosters and Colorado, were reported.

The following list gives the record of the various pests and host plants which were found in nurseries during the last season:

On Apple
- Aphis
- Buffalo tree hopper
- Oyster shell scale
- Red-humped apple-tree caterpillar
- Round-headed apple borer
- Saddle-back caterpillar
- San Jose scale
- Trumpet leaf miner
- Scurfy scale
- Woolly aphis

Ash (Green)
- Aphis

Ash (Mountain)
- San Jose scale
- Woolly aphis

Boxelder
- Mite work
- Aphis

Compass Cherries
- Red-humped apple-tree caterpillar

Currant (Red)
- Aphis
- Saw fly

Elms
- Cockscomb gall
- Aphis
- Scurfy scale
- Woolly aphis
- San Jose scale

Grapes
- Phylloxera
- Lilac borer

Plum
- Aphis
- Black aphis
- Curculio
- Red-humped apple-tree caterpillar
- Scurfy scale

Poplar
- Poplar beetle

Raspberry (Red)
- Byturus
- Snowy tree cricket

Snowball
- Aphis

Spirea
- Aphis

Strawberries
- Leaf curler
- Nematodes

White Pine
- White Pine blight (Aphid)

Willow
- Aphis
- Poplar beetle

PLANT DISEASES

Apple
- Cedar rust
- Fire blight canker
- Heart rot
- Scab
- Shot hole fungus
- Tipburn

Currant (Red)
- Leaf rust

Plum
- Brown rot (on twigs)
- Mildew
- Shot hole fungus

Raspberries (Black cap)
- Anthracnose
- Crown gall

Raspberries (Red)
- Anthracnose

Currant (Black)
Shot hole fungus
Grape
Powdery mildew
Moneysuckle (Lonicera)
Mildew
Lilac
Mildew
Maple
Tar spot, Maple
Cane blight
Crown gall
Yellows (Bad)
Roses
Mildew (Bad)
Spirea
Mildew
Strawberries
Leaf Anthracnose

FINANCIAL STATEMENT

Dec. 1, 1914, to Dec. 1, 1915.

Cash on hand	$1,850.10	
Appropriation for 1915-16	3,000.00	
		$4,850.10
Deputy Inspector's Salary	$1,383.30	
Clerk and Accountant	150.00	
Expert Assistants, Traveling Expenses, etc	338.05	
Miscellaneous (Apparatus, Office Supplies, etc.)	91.81	
Printing	29.25	
Telephone	10.00	
Traveling expenses of Deputy Inspector	1,187.15	
		3,189.56
Balance		$1,660.54

COLLECTIONS—NURSERY FEES.

Cash on hand Dec., 1914	$10.00
8 certificates issued to dealers (1915)	40.00
115 certificates issued to nurserymen (1915)	575.00
	$625.00
Oct. 6, 1915. Deposited as per State Treasurer's receipt No. 2883	$485.00
Dec. 2, 1915. Deposited as per State Treasurer's receipt No. 3063	140.00
	$625.00

NURSERY INSPECTION IN MINNESOTA.

1916.

The season of 1916 was favorable for the development of diseases and insects in the nurseries, the usually common pests being much more abundant than in most years. The Tussock Moth was especially abundant, and did considerable damage in certain nurseries. One of the red spiders was so plentiful in some nurseries as to make entire blocks of stock look sick, with leaves wilted and brownish. (In some cases the drouth helped to make this condition.) Leaf hoppers, fall web worm, aphids on apples, plums and currants, poplar beetle on poplars and willows, snowy tree cricket on raspberry, blight on poplar, anthracnose on gooseberries and currants, leaf spot on currants, blight on apple, gray bark or spur blight, anthracnose and crowngall on cane fruits were some of the pests reported.

No new infestation of San Jose scale was found this year, and those found the two years previous have been completely stamped out.

The startling part of last season's work was, of course, the finding of white pine blister rust in two of our nurseries. But by heroic methods on the part of the owners of these nurseries we feel justified in saying it has been stamped out within the boundaries of both places.

We propose to keep all files in the clerk's room and under her direction. An assistant on full time should be secured for the clerk.

All lists of equipment held by each individual man should be filed with the clerk, and each man should be responsible to the clerk for the proper return of same.

The question of the use of an auto has come up often and in the spring of 1915 Mr. Peake purchased a car privately and charged mileage to pay the running expense. The last two seasons, 1915 and 1916, the inspection work has largely been carried on with the use of this auto in making our circuits and although the cost is somewhat more than railroad fare and auto livery (when only one inspector is concerned), yet the work is so greatly facilitated that it would be a step toward inefficiency to attempt to do the work without an auto. Further, when two or more inspectors are working together it is a saving. It does not seem just, however, that the inspectors should have to invest their own capital in a car on the small salary paid, especially when it has been shown that the mileage does not quite pay current expenses on the car, to say nothing of depreciation in value, interest on the investment, fire and theft risk, tires, etc. That is the reason for asking for a small car, equipped to do the work, to be owned by the state. The car should be light and should be equipped with facilities to carry not only the personal luggage of the inspectors, but also equipment for a field laboratory, such as a dissecting binocular, two spencer hand lens, typewriter, stationery, killing bottles, two breeding cages, etc.

If there are two regular inspectors on this car all of the time it probably can be run for about 7c a mile, which would be fully as cheap as railroad fare and livery hire for two men and from two to three times as efficient in the work of inspecting throughout the state. If this car is obtained we expect to co-operate with the county agents working with each for a day or two when in his territory and in this way being of educational value to the farmer who is growing fruit of any kind.

The following circuits are the most economical as to time and money in the inspection of nurseries if a car is to be used.

CIRCUIT A.

Nurseries in and near Minneapolis and St. Paul, and the Lake Minnetonka region, including the following:

The Baker Nursery, the Board of Park Commissioners of Minneapolis, the Farmer Nursery, the Franklin Nursery, the Minneapolis Nursery, the Rose Hill Nursery, the Hunter Nursery, the Ellison Nursery, Ruedlinger Nursery, the Vine Grove Nursery, all of Minneapolis; Cabinwood Nursery, the Deephaven Nursery, the Ferodowill Nursery, the Hawkinson Nursery, the University Fruit Breeding Farm, the Lake View Nursery and Fruit Farm, the Brackett Nursery, Highlands Fruit Farm, Minnetonka Old Fashioned Flower Garden, the Daniels Nursery, the Minnetonka Nursery, around Lake Minnetonka; the Tong Nursery, Long Lake, Hughart's Sons' Nursery, Hamel, both also in the Lake Minnetonka district; the J. C. B. Anderson Nursery, the Hoyt Nursery, the Bailey Nursery, the Park Nurseries, St. Paul Park and Cemeteries, all of St. Paul.

CIRCUIT B.

St. Paul to Newport and St. Paul Park, Red Wing, Lake City, Plainview, La Crescent, Houston, Preston, Canton, Mabel, Spring Valley, Austin, Waltham, Albert Lea, Owatonna, Mantorville, Byron, Rochester, West Concord, Kenyon, Cannon Falls, return to St. Paul.

CIRCUIT C.

St. Paul to Farmington, Northfield, Lonsdale, Faribault, Medford, Deerfield, Waterville, Mankato, St. Peter, Winthrop, New Ulm, Garden City, St. James, Sherburn, Fairmont, Winnebago, Adrian, Luverne, Fulda, Jeffers, Lamberton, Tracy, Tyler, Marshall, Cottonwood, Minneota, Canby, Marietta, Madison, Dawson, Watson, Montevideo, Granite Falls, Sacred Heart, Renville, Olivia, Raymond, Willmar, Atwater, Litchfield, Dassel, Cokato, Howard Lake, Delano, Buffalo, Rockford, Hamel, St. Paul.

CIRCUIT D.

St. Paul to Lakeland, Stillwater, Taylors Falls, Lindstrom, Cambridge, Pine City, Hinckley, Onamia, Askov, Kerrick, Nemadji, Cloquet, Duluth, Eveleth, Virginia, Hibbing, Grand Rapids, Grayling, Kimberly, Aitkin, Brainerd, Hubart, Pine River, Little Falls, St. Cloud, Monticello, St. Paul.

CIRCUIT E.

St. Paul to Paynesville, Starbuck, Alexandria, Elbow Lake, Fergus Falls, Battle Lake, Parkers Prairie, Perham, Crookston, East Grand Forks, Warren, Mentor, Bagley, Bemidji, Black Duck, Cass Lake, Itasca Park, Nevis, Hubbard, Eagle Bend, Long Prairie, Grey Eagle, Freeport, Avon, Collegeville, St. Paul.

These routes include most of the towns where nurseries will be inspected. In carrying out the white pine blister rust survey the number of towns and plantings visited will total many times this list.

SUMMARY OF FOREIGN NURSERY STOCK RECEIPTS.

Dec. 1, 1915, to Dec. 1, 1916.

Shipped from	No. of Cases.	No. of Plants.
Holland	372	128,758
Belgium	104	3,831
France	55	385,280
England	6	15,154
Bermuda	1	200
Japan	28	1,573
Scotland	3	16,000
Total	569	550,796

This represents 108 shipments. All plants were inspected by us. While no stock has been received from Germany during the year, it is surprising to note that in this, the third year of the war, there were 32,466 more plants imported than in the second year (1915).

This importation of foreign stock is a menace to our domestic plants and trees, however, because of the diseases and insects, which may find their way into the country in spite of a thorough inspection of the stock, and we believe it would be highly advisable for the United States to discontinue all importations of foreign stock to this country with the exception of such stock as is brought in by the U. S. Dept. of Agr. for experimental purposes.

When we look at the vast amount of damage done in the past, and the property loss at the present time caused by these imported pests, as in the case of the chestnut blight, the citrus canker, the brown tail moth, and the white pine blister rust, we feel that a quarantine against all European stock is advisable.

MINNESOTA NURSERIES INSPECTED AND HOLDING CERTIFICATES GOOD UNTIL NOVEMBER, 1917.

Name of Nursery		Certificate Number			Inspected by
The Albert Lea Nursery O. M. Peterson	Albert Lea	843	Aug.	24	F. L. Washburn
Minnesota State Nursery (Dealer)	Albert Lea	39			
The South Side Nursery Martin Fridholm	Albert Lea	842	Aug.	24	F. L. Washburn
Wedge Nursery Clarence Wedge	Albert Lea	884	Sept.	14	G. W. Peake
Alexandria Fruit Farm and Nursery W. H. Horton	Alexandria	859	Sept.	14	W. D. Valleau
Ferndale Ludvig Mosback	Askov	888	Sept.	11	W. D. Valleau
Atwater Fruit Farm (Dealer)	Atwater	38			
The Austin Nursery C. F. Woodle	Austin	845	Aug.	24	F. L. Washburn
The Turtle Creek Nursery J. M. Lindsay	Austin	844	Aug.	24	F. L. Washburn
A. N. Kinsman, Inc. (Dealers)	Austin	32	Sept.	1	
The Battle Lake Nursery A. A. DeSmidt	Battle Lake	925	Sept.	13	W. D. Valleau
The J. E. Swedberg Nursery (Dealers)	Battle Lake	27	April	6	
Laudenback Nursery Tom Laudenback	Bagley	863	Sept.	4	G. M. Corzet

Name of Nursery		Certificate Number			Inspected by
Wah-wah-taysee Lodge T. W. Ingersoll	Buffalo	855	Sept.	13	F. L. Washburn
The Byron Nursery F. E. Cutting	Byron	928	Sept.	1	G. W. Peake O. J. Wenzel,
Oslund's Nursery N. N. Oslund	Cambridge	909	Sept.	18	G. M. Conzet
Peter Siverts	Canby	929	Sept.	29	Freeman Weiss
Fillmore County Nursery Geo. F. Snyder	Canton	858	Sept.	13	Freeman Weiss
North Star Farm J. W. Beckman	Cokato	922	Sept.	20	F. L. Washburn
Wright County Nursery John Eklof	Cokato	915	Sept.	21	F. L. Washburn
Schuster Nursery Edward W. Schuster	Crookston	908	Sept.	19	G. M. Conzet
Delano Nursery Chas. Sell	Delano	856	Sept.	20	F. L. Washburn
Greysolon Nursery C. E. Roe	Duluth	930	Sept.	12	W. D. Valleau
Taylor's Eagle Bend Nursery T. W. Taylor	Eagle Bend	898	Oct.	13	G. W. Peake
East Grand Forks Nursery Oscar Wick	East Grand Forks	932	Sept.	19	G. M. Conzet
Brackett Nursery A. Brackett	Excelsior	834	Aug.	15	F. L. Washburn
The Deephaven Nursery A. O. Hawkins	Excelsior	849	Sept.	1	F. L. Washburn
The Highlands Fruit Farm C. P. Jackson Land Co.	Excelsior	835	Aug.	15	F. L. Washburn
Chas. Hawkinson Nursery Chas. Hawkinson	Excelsior	850	Sept.	1	F. L. Washburn
Minnetonka Old Fashioned Flower Garden Mrs. N. S. Sawyer	Excelsior	836	Aug.	15	F. L. Washburn
Schmid's Nursery William Schmid	Excelsior	825	April	18	Geo. Nelson
Thurmann's Nursery Co. W. J. C. Thurmann	Excelsior	827	May	5	G. W. Peake
Zumbra Heights Fruit and Poultry Farm August Sauter	Excelsior	871	Sept.	25	F. L. Washburn
Amber Lake Nursery Co. P. C. Christensen	Fairmont	872	Oct.	31	G. W. Peake
Commercial Nurseries of Fairmont (Dealers)	Fairmont	36	Oct.	30	G. W. Peake
Fairmont Nurseries G. D. McKisson	Fairmont	927	Oct.	31	G. W. Peake
The St. John Nursery Co. B. E. St. John	Fairmont	823	Mar.	19	G. W. Peake
The Andrews Nursery John P. Andrews	Faribault	885	Nov.	5	G. W. Peake
Brand Nursery Co.	Faribault	857	Aug.	19	Peake & Wenzel
Farmers' Seed & Nursery Co. Wm. Kueker	Faribault	883	Aug.	16	Peake & Wenzel
Northern Nursery Co. (Dealers)	Faribault	37			
Evergreen Nursery O. A. Th. Solem	Halstad	911	Sept.	21	G. M. Conzet
Hughart's Sons' Nursery Hughart's Sons	Hamel	837	Aug.	18	F. L. Washburn
The Groveland Nursery W. B. Miller	Hopkins, R. F. D.	824	April	13	
Vinegar Hill Nursery Wm. Sandrock	Houston	893	Sept.	12	Freeman Weiss
Howard Lake and Victor Nurseries W. H. Eddy	Howard Lake	873	Sept.	20	F. L. Washburn
Jeffers Trial Station Dewain Cook	Jeffers	931	Sept.	30	Peake & Weiss
The Kenyon Nursery J. A. Mogren & Sons	Kenyon	926	Sept.	1	G. W. Peake
Oak Grove Nursery P. H. Volstad	Kenyon	914	Aug.	31	G. W. Peake
The South Kenyon Nursery E. J. Hershaug	Kenyon	874	Sept.	1	G. W. Peake
Kerrick Fruit Farm Margaret Culle	Kerrick	916	Sept.	21	C. D. Valleau
Ayers Jack Pine Nursery H. B. Ayers	Kimberley	891	June	17	R. C. Rose

Name of Nursery		Certificate Number			Inspected by
The Jewell Nursery Co.	Lake City	829	Aug.	29	G. W. Peake, G. M. Conzet, O. J. Wanzel, Geo. Nelson, Freeman Weiss
The Johnson Nursery P. G. Johnson	Lake City	882	Aug.	22	Conzet & Peake
National Nursery Co. J. L. Anderson	Lake City	851	Aug.	22	G. W. Peake
Sugar Loaf Valley Nursery Co. Moseman Bros.	Lake City	862	Aug.	23	G. M. Conzet
Tolleson Nursery Co. G. A. Tolleson	Lake City	890	Aug.	22	Weiss & Peake
The Mayfield Nurseries L. L. May	Lakeland	900	Sept.	27	Conzet, Peake & Nelson
The Chisago Lake Nursery Ludwig Carlson	Lindstrom	875	June	12	G. W. Peake
The Ferguson Nursery (Dealers) W. C. Ferguson	Litchfield	35			
The Daniels Nursery Franc P. Daniels	Long Lake	831	Aug.	8	F. L. Washburn
The Minnetonka Nursery Douglas Winter	Long Lake	861	May	17	G. W. Peake
The Lonsdale Nursery John P. Vikla	Lonsdale	923	Nov.	2	G. W. Peake
The Madison Nursery M. Soholt	Madison	876	Sept.	28	G. W. Peake
Mankato Nursery L. Z. Smith	Mankato	899	Oct.	27	G. W. Peake
M. M. Sinotte (Dealer)	Mankato	31	July	5	
Dodge County Nursery W. E. Fryer	Mantorville	887	Sept.	2	Peake & Wenzel
Orton Park Nursery C. J. Orton	Marietta	918	Sept.	28	G. W. Peake
Minnesota State Nursery Co. E. C. Eaker	Marshall	886	Sept.	29	Peake & Weiss
The Deerfield Nursery Co. J. F. Brady	Medford	933	Nov.	6	G. W. Peake
The Medford Nursery Grace Patton Eaton	Medford	840	Aug.	22	F. L. Washburn
C. B. Finsaas	Mildred	889	Sept.	27	G. M. Conzet
Harry Franklin Baker	Minneapolis 4629 Harriet Blvd.	904	Oct.	2	G. W. Peake
W. H. Boefferding Co. (Dealers)	Minneapolis 1221 Washington N.	30	May	2	
Cedar Hill Nursery C. N. Ruedlinger	Minneapolis 2929 Colfax S.	905	Nov.	16	F. L. Washburn
The Farmer Nursery E. A. Farmer	Minneapolis Linden Hills Sta.	919	Oct.	6	G. W. Peake
The Minneapolis Park Board Theo. Wirth	Minneapolis 327 City Hall	892	Nov.	15	F. L. Washburn
Northrup, King & Co. (Dealers)	Minneapolis 26 Hennepin Ave.	33	Sept.	6	
Rose Hill Nursery John Hawkins	Minneapolis Eustis & Como S. E.	920	Aug.	16	G. W. Peake Geo. Nelson
Teigland's Nursery J. L. Teigland	Minneota	877	Sept.	29	G. W. Peake
Combercroft Farm & Nursery G. E. MacComber	Nemadii	924	Sept.	12	C. D. Valleau
Nevis Fruit Breeding Station Jas. Arrowood	Nevis	910	Sept.	29	G. M. Conzet
F. J. Hipp	New Brighton, Box 72	848	Aug.	29	G. W. Peake
I. O. Bailey	Newport	921	Sept.	21	F. Weiss
Pioneer Nursery Co. Wm. Pfaender	New Ulm	860	Oct.	1	Peake & Weiss
Northfield Seed & Nursery Co. Jas. M. Punderson	Northfield	839	Aug.	22	F. L. Washburn
North St. Paul Horticultural Farm I. K. Dixon & B. Ballard	North St. Paul	826	April	20	M. Dorsey
Dunsmore Nursery Henry Dunsmore	Olivia	869	Sept.	26	Peake & Weiss
Clinton Falls Nursery Co. Thos. E. Cashman	Owatonna	852	Aug.	25	O. J. Wenzel
Mitchell Nursery Co. D. M. Mitchell	Owatonna	867	Aug.	27	Wenzel & Weiss
The Owatonna Nursery L. J. Wesley	Owatonna	841	Aug.	23	F. L. Washburn
The Elmwood Select Nursery Frank Brown & Son	Paynesville	907	Sept.	15	C. D. Valleau

Name of Nursery		Certificate Number			Inspected by
J. H. Bauer, Nurseryman	Perham	894	Sept.	13	C. D. Valleau
Minnesota Northern Nurseries. R. E. Killmer & O. J. Graham.	Pine City	854	Sept.	11	C. D. Valleau
The Preston Nursery. C. E. Snyder	Preston	895	Sept.	14	F. Weiss
J. O. Runsten	Princeton	901	Sept.	17	S. Marcovitch
Silver Lake Plant Farm. Herman J. Lowell	Princeton, R. F. D. 2	906	Sept.	17	S. Marcovitch
Glendale Fruit Farm. G. A. Anderson	Renville	878	Sept.	26	Peake & Weiss
Lake Sarah Specialty Farm. F. C. Erkel	Rockford	838	Aug.	18	F. L. Washburn
Sacred Heart Nursery. J. Flagstad & Sons	Sacred Heart	868	Sept.	27	Peake & Weiss
The St. Cloud Nursery Co. (Dealers)	St. Cloud	29	May	19	
The St. James Nursery & Greenhouses. J. J. Hill	St. James	903	Oct.	27	G. W. Peake
The J. C. B. Andersson Nursery. J. C. B. Andersson	St. Paul	853	May	20	G. W. Peake
Emporium Mercantile Co. (Dealers)	St. Paul	28	April	20	
Hoyt Nursery Company. C. B. Hoyt	St. Paul, Hoyt & Hamline Ave.	917	Aug.	25	Geo. Nelson
Killmer's Northern Nurseries. E. C. Killmer	St. Paul, 1511 Raymond Ave.	828	May	25	G. W. Peake
The Park Nurseries. Holm & Olson, Inc.	St. Paul, 20 W. 5th St.	879	Aug.	12	O. J. Wenzel
Nicollet & Sibley County Nurseries. C. Edwin Swenson	St. Peter	897	Oct.	26	G. W. Peake
The Meininger Nursery. L. Meininger	Sherburn	913	Oct.	31	G. W. Peake
Minnewaska Nursery. Paul P. Klevann	Starbuck	870	Sept.	14	C. D. Valleau
Strand's Nursery. Geo. W. Strand	Taylors Falls	866	Oct.	29	F. L. Washburn
The Tyler Nursery. J. P. Erickson	Tyler	865	Sept.	29	G. W. Peake
E. L. Thomas & Son (Dealers)	Vergas	34			
Maplehurst Nursery. Grace E. Kimball	Waltham	864	Sept.	25	Geo. Nelson
Cabinwood Nursery. S. J. Wetherall	Wayzata, R. F. D. 1	832	Aug.	9	F. L. Washburn
Ferodowill Nurseries. Frank X. Ferodowill	Wayzata, R. F. D. 1	833	Aug.	8	F. L. Washburn
West Concord Nursery. Fred Cowles	West Concord	881	Sept.	2	Peake & Wenzel
The S. D. Richardson Nursery. S. D. Richardson	Winnebago	880	Nov.	1	G. W. Peake
Winnebago Nursery. Guy Van Duzee	Winnebago	912	Nov.	1	G. W. Peake
The Pfeiffer Nursery. C. A. Pfeiffer & Son	Winona	847	Aug.	26	F. L. Washburn
The University Fruit-Breeding Farm Nursery. State of Minnesota	Zumbra Heights	896	Sept.	25	F. L. Washburn

FINANCIAL STATEMENT.

Dec. 1, 1915, to Dec. 1, 1916.

Balance, Dec. 1, 1915	$1,660.54	
Appropriation, 1916-17	3,000.00	
		$4,660.54
Deputy Inspector's Salary	$1,552.50	
Clerical Service	104.13	
Expert Assistants, Traveling Expenses, etc.	778.63	
Miscellaneous (Apparatus, Office Supplies, etc.)	65.15	
Printing	61.60	
Telephone	15.55	
Traveling Expenses of Deputy Inspector	851.03	
Unused Balance	2.41	
		$3,431.00
Balance, Dec. 1, 1916		$1,229.54

COLLECTIONS—NURSERY FEES.

Cash on hand, December, 1915 (two fees)	$10.00
108 Certificates issued to Nurserymen (1916)	540.00
13 Certificates issued to Dealers (1916)	65.00
	$615.00

Dec. 6, 1916.	Deposited as per State Treasurer's receipt No. 4652	$382.34
	Hennepin County Bank exchange charges	2.66
Dec. 19, 1916.	Deposited as per State Treasurer's receipt No. 4711	205.00
Feb. 7, 1916.	Deposited as per State Treasurer's receipt No. 4934	25.00
		$615.00

INSPECTIONS FOR WHITE PINE BLISTER RUST, SEASON OF 1916, WITH NAMES OF INSPECTORS.

Owner	Town	Date 1916	Inspector	Number of Ribes	Number of Pines
O. M. Peterson	Albert Lea	June 3.	Conzet, Peake	.....	100
O. M. Peterson	Albert Lea	Aug. 24.	Washburn, Peake	.....	100
Martin Fridholm	Albert Lea	June 2.	Peake, Conzet	.....	.....
Martin Fridholm	Albert Lea	Aug. 24.	Washburn, Peake	.....	.....
Clarence Wedge	Albert Lea	June 3.	Conzet, Peake	.....	10,000
Clarence Wedge	Albert Lea	Sept. 14.	Peake	.....	11,000
E. C. Baker	Albert Lea	June 2.	Peake, Conzet	.....	.....
W. H. Horton	Alexandria	Sept. 14.	Valleau	Few	.....
State of Minnesota	Arago	Sept. 25.	Conzet	.....	405,000
Ludvig Mosbaek	Askov	Sept. 11.	Valleau	1,000	.....
C. F. Woodle	Austin	Aug. 24.	Washburn, Weiss	.....	.....
J. M. Lindsay	Austin	Aug. 24.	Washburn, Weiss	.....	.....
W. H. Day	Bald Eagle	May 30.	Conzet	.....	.....
Tom Laudenback	Bagley	Sept. 4.	Conzet	.....	.....
A. A. DeSmidt	Battle Lake	Sept. 13.	Valleau	.....	.....
L. P. Anderson	Bemidji	Sept. 24.	Conzet	.....	.....
T. W. Ingersoll	Buffalo	Sept. 13.	Washburn	.....	.....
F. E. Cutting	Byron	June 12.	Peake	.....	9,016
F. E. Cutting	Byron	Sept. 1.	Peake, Wenzel	.....	9,000
N. N. Oslund	Cambridge	Sept. 18.	Marcovitch	.....	.....
Peter Siverts	Canby	Sept. 29.	Weiss, Peake	.....	.....

Owner	Town	Date 1916	Inspector	Number of Ribes	Number of Pines
George F. Snyder	Canton	Sept. 13.	Weiss	.....	.....
J. W. Beckman	Cokato	Sept. 20.	Washburn	.....	.....
John Eklof	Cokato	Sept. 21.	Washburn	.....	.....
A. L. and F. Lee	Cokato	Sept. 21.	Washburn	.....	.....
Edw. W. Schuster	Crookston	Sept. 18.	Conzet	.....	.....
Charles Sell	Delano	Sept. 20.	Washburn	.....	.....
C. E. Roe	Duluth	Sept. 12.	Valleau	.....	.....
T. W. Taylor	Eagle Bend	Oct. 13.	Peake	.....	.....
Oscar Wick	East Grand Forks	Sept. 19.	Conzet	300	12
A. Brackett	Excelsior	Aug. 15.	Washburn	.....	.....
A. O. Hawkins	Excelsior	May 31.	Conzet, Peake	5,000	100
A. O. Hawkins	Excelsior	Sept. 1.	Washburn	.....	.....
P. M. Perry	Excelsior	Oct. 7.	Washburn, Peake	.....	.....
C. P. Jackson Land Co.	Excelsior	Aug. 15.	Washburn	.....	.....
Charles Hawkinson	Excelsior	May 31.	Conzet, Peake	.....	.....
Charles Hawkinson	Excelsior	Sept. 1.	Washburn	.....	.....
Mrs. N. S. Snyder	Excelsior	Aug. 15.	Washburn	.....	.....
William Schmid	Excelsior	Apr. 18.	Nelson	.....	.....
August Sauter	Excelsior	Sept. 25.	Washburn	.....	.....
P. C. Christensen	Fairmont	Oct. 31.	Peake	.....	.....
G. D. McKisson	Fairmont	Oct. 31.	Peake	.....	.....
B. E. St. John	Fairmont	Mar. 19.	Peake	.....	.....
John P. Andrews	Faribault	June 8.	Conzet, Peake	.....	.....
John P. Andrews	Faribault	Nov. 5.	Peake	.....	160
Brand Nursery Co.	Faribault	June 7.	Peake	.....	.....
Brand Nursery Co.	Faribault	Aug. 19.	Peake	.....	.....
William Kueker	Faribault	June 7.	Peake	.....	535
William Kueker	Faribault	Aug. 16.	Peake, Wenzel	.....	960
J. A. Bovey	Ferndale	July 10.	Washburn	.....	8
O. A. Th. Solem	Halstad	Sept. 21.	Conzet	.....	.....
Hughart's Sons	Hamel	Aug. 18.	Washburn	50	400
William Sandrock	Houston	Sept. 12.	Weiss	.....	.....
W. H. Eddy	Howard Lake	Sept. 20.	Washburn	27,092	1,302
Dewain Cook	Jeffers	Sept. 30.	Peake, Weiss	.....	.....
J. A. Mogren & Sons	Kenyon	June 9.	Peake	.....	.....
J. A. Mogren & Sons	Kenyon	Sept. 1.	Peake	.....	14
P. H. Volstad	Kenyon	Aug. 31.	Peake	.....	.....
E. J. Hershang	Kenyon	Sept. 1.	Peake	40	26
Jewell Nursery	Lake City	May 26.	Washburn, Peake	.....	670
Jewell Nursery	Lake City	Aug. 22.	Peake	.....	.....
		Aug. 23.	Conzet	.....	.....
		Aug. 24.	Nelson, Weiss, Wenzell	90,000	4,000
P. G. Johnson	Lake City	Aug. 22.	Conzet, Peake	20	.....
J. L. Anderson	Lake City	Aug. 22.	Conzet, Peake	9,065	439
Moseman Bros.	Lake City	Aug. 23.	Conzet, Peake	.....	.....
G. A. Tolleson	Lake City	Aug. 22.	Weiss, Peake	3,000	.....
L. L. May	Lakeland	May 27 and 28.	Peake, Conzet	.....	1,550
L. L. May	Lakeland	May 29.	Peake	....	1,200
L. L. May	Lakeland	June 12.	Washburn	.....	.....
L. L. May	Lakeland	June 26.	Washburn, Peake	.....	.....
L. L. May	Lakeland	June 28.	Peake	.....	.....
L. L. May	Lakeland	June 30 to Aug. 21	Coe, Peake,		

Owner	Town	Date 1916	Inspector	Number of Ribes	Number of Pines
L. L. May	Lakeland	July 2, 3, 6, 7, 8.	Washburn, Peake		
L. L. May	Lakeland	July 10.	Washburn		
L. L. May	Lakeland	July 15.	Peake		
L. L. May	Lakeland	Sept. 26 and 27.	Nelson		
L. L. May	Lakeland	Oct. 1.	Coe		
L. L. May	Lakeland	Oct. 21 to 24.	Coe		
Ludwig Carlson	Lindstrom	May 30.	Conzet, Peake		622
Ludwig Carlson	Lindstrom	June 12.	Peake, Conzet		
D. Winter	Long Lake		Peake	250	525
Franc P. Daniels	Long Lake	Aug. 8.	Washburn		
George Tong	Long Lake	Aug. 8.	Washburn		
John P. Vikla	Lonsdale	Nov. 2.	Peake		
C. E. Older	Luverne	Sept. 30.	Weiss, Peake		
M. Soholt	Madison	Sept. 28.	Peake, Weiss	3,000	
L. Z. Smith	Mankato	Oct. 27.	Peake		
W. E. Fryer	Mantorville	June 10 to 12.	Peake	300	4,000
W. E. Fryer	Mantorville	Sept. 2.	Peake, Wenzell		
C. J. Orton	Marietta	Sept. 28.	Peake, Weiss		
	Marine Mills	Sept. 10 and 11.	Peake		
E. C. Eaker	Marshall	Sept. 29.	Peake, Weiss		
J. F. Brady, Sr.	Medford	Nov. 6.	Peake		
Grace Patten Eaton	Medford	Aug. 22.	Washburn		
C. B. Finsaas	Mildred	Sept. 27.	Conzet		
Harry Franklin Baker	Minneapolis	June 1.	Washburn	100	150
Harry Franklin Baker	Minneapolis	Oct. 2.	Peake		
E. A. Farmer	Linden Hills Sts., Mpls.	June 6.	Peake		
E. A. Farmer	Minneapolis	Oct. 6.	Peake		
Mpls. Park Board	Lake of Isles Blvd.	June 3.	Washburn		8
	Glenwood Pk.	June 3.	Washburn		1,000
	Columbia Hts.	June 3.	Washburn		500
John Hawkins	P. O. Box 495 Minneapolis	June 2.	Washburn		20
John Hawkins	Minneapolis	Aug. 16.	Peake, Nelson	15,000	200
C. C. Hunter	Minneapolis	June 7.	Washburn		112
C. C. Hunter	Minneapolis	Nov. 21.	Peake		
J. L. Teigland	Minneota	Sept. 29.	Peake, Weiss		
O. F. B. Gustafson	Mound	July 9.	Washburn		12
G. E. MacComber	Nemadji	Sept. 12.	Valleau		
James Arrowood	Nevis	Sept. 29.	Conzet		
J. O. Bailey	Newport	Sept. 21.	Weiss, Marcovitch		
William Pfaender	New Ulm	Oct. 1.	Peake, Weiss		
Jas. M. Punderson	Northfield	June 1.	Conzet, Peake		
Jas. M. Punderson	Northfield	Aug. 22.	Washburn, Peake, Wenzel	2,000	100
Henry Dunsmore	Olivia	Sept. 26.	Peake, Weiss		
Thos. E. Cashman	Owatonna	Jun. 4-5.	Peake, Conzet	100,000	25,000
Thos. E. Cashman	Owatonna	June 15.	Washburn		
Thos. E. Cashman	Owatonna	Aug. 25.	Wenzel, Weiss, Conzet, Peake		
D. M. Mitchell	Owatonna	June 2.	Conzet, Peake		

Owner	Town	Date 1916	Inspector	Number of Ribes	Number of Pines
D. M. Mitchell	Owatonna	Aug. 27.	Wenzel, Weiss, Peake	.....	.....
L. J. Wesley	Owatonna	Aug. 23.	Washburn	.....	.....
Frank Brown & Sons	Paynesville	Sept. 15.	Valleau	.....	.....
J. H. Bauer	Perham	Sept. 13.	Valleau	.....	.....
R. E. Killmer and O. J. Graham	Pine City	Sept. 11.	Valleau	.....	.....
Benj. Rochell and Geo. Benz	Pine Hollow Creek	Oct. 5.	Washburn	.....	.....
C. E. Snyder	Preston	Oct. 3.	Weiss	800	3,000
H. W. Harrison	Rochester	Aug. 25.	Washburn	.....	.....
H. W. Harrison	Rochester	Sept. 1.	Peake	.....	.....
F. C. Erkel	Rockford	Aug. 18.	Washburn	.....	.....
J. J. Hill	St. James	Oct. 27.	Peake	.....	.....
J. C. B. Anderson	1285 Portland Av., St. Paul.	May 20.	Peake	.....	.....
C. B. Hoyt	Hoyt & Hamline Avs., St. Paul	May 31.	Washburn	.....	12
C. B. Hoyt	St. Paul	Aug. 25.	Nelson	.....	.....
Holm & Olson, Inc.	20 W. 5th St., St. Paul	May 31.	Conzet, Peake	2,800	500
Holm & Olson, Inc.	St. Paul	June 6.	Peake	.....	.....
Holm & Olson, Inc.	St. Paul	June 27.	Peake	.....	.....
Holm & Olson, Inc.	St. Paul	Aug. 12.	Wenzel, Conzet, Peake, Nelson	.....	.....
C. Edwin Swenson	St. Peter	Oct. 26.	Peake	.....	.....
J. Flagstad & Sons	Sacred Heart	Sept. 27.	Peake, Weiss	2,500	1,000
L. Meininger	Sherburn	Oct. 21.	Peake	.....	.....
Paul P. Klevann	Starbuck	Sept. 14.	Valleau	.....	.....
.....	Stillwater	June 21.	Peake	.....	.....
.....	Stillwater	June 26.	Peake	.....	.....
Geo. W. Strand	Taylors Falls	May 24.	Peake	.....	100
Geo. W. Strand	Taylors Falls	May 30.	Conzet, Peake	.....	300
.....	Taylors Falls	June 28, 29 & 30.	Peake	.....	.....
.....	Taylors Falls	July 4, 5 & 6.	Peake	.....	.....
.....	Taylors Falls	July 6.	Washburn	.....	.....
.....	Taylors Falls	July 16 to 24	Peake	.....	.....
.....	Taylors Falls	July 20 to 22	Washburn	.....	.....
.....	Taylors Falls	Sept. 3, 4, 5, 8, 9.	Peake	.....	.....
.....	Taylors Falls	Sept. 18.	Washburn	.....	.....
.....	Taylors Falls	Sept. 18 and 19.	Washburn, Peake	.....	.....
.....	Taylors Falls	Sept. 23 and 24.	Peake	.....	.....
Geo. W. Strand	Taylors Falls	Oct. 29.	Washburn	.....	.....
J. P. Erickson	Tyler	Sept. 29.	Peake, Weiss	1,000	.....
S. J. Wetherall	R.F.D. No. 1, Wayzata	Aug. 9.	Washburn	.....	.....
Frank X. Ferodowill	R.F.D. No. 1, Wayzata	June 3.	Washburn	.....	30

Frank X. Ferodowill	R.F.D. No. 1, Wayzata	Aug. 8.	Washburn	.....	.....	.....
Carl DeLaittre	Wayzata	July 3.	Washburn	.....	.....	Few
R. C. Bagley	Wayzata	July 5.	Washburn	.....	.....	1
Fred Cowles	West Concord.	June 9.	Peake	.....	.....	.....
Fred Cowles	West Concord.	Sept. 2.	Peake, Wenzel...	.....	.....	.....
S. D. Richardson	Winnebago ..	Nov. 1.	Peake	.....	.....	.....
Guy Van Duzee	Winnebago ..	Nov. 1.	Peake	.....	.....	.....
C. A. Pfeiffer & Son	Winona	Aug. 26.	Washburn	.....	4,000	42
Fruit Breeding Farm	Zumbra Hts..	Sept. 25.	Washburn	.....	5,000	.....

The following is a list of the men and the time spent by them in the survey and eradication of White Pine Blister Rust for the season of 1916:

G. W. Peake	Full time.
G. M. Conzet	Aug. 16 to 31 inc.
	Sept. 19 to 30 inc.
O. J. Wenzel	Aug. 6 to Sept. 2 inc.
R. C. Rose	July 16 to 31 inc.
	Aug. 1 to 11 inc.
D. M. Badger	July 16 to 31 inc.
	Aug. 1 to 11 inc.
J. P. Jensen	June 27 to Aug. 7 inc.
E. S. Reynolds	June 23 to Aug. 7 inc.
Maynard Coe	June 28 to Oct. 5 inc.
W. D. Valleau	Sept. 10 to 16 inc.
George Nelson	July 25, 27, 28.
	Aug. 20 to 24 inc.
	Aug. 1, 9, 16.
	Sept. 25 to 27 inc.
Freeman Weiss	Aug. 20 to 24 inc.
	Aug. 27 to 31 inc.
	Sept. 11 to 15 inc.
	Sept. 25 to Oct. 1 inc.
S. Marcovitch	Sept. 16 to 19 inc.
John P. Andrews	June 22, 26, 27.
	July 21.
Edna Seavey (Clerical Help)	June 7, 8, 23, 24.
	July 18, 19, 20, 21, 22.
Harriet C. Johnson (Clerical Help)	July 5, 6, 10, 12, 13 to 18 inc.
	July 20, 22, 24, 25.
	Sept. 16, 23.
Alice M. Bailey	3 days.
Victor Booton	Aug. 1 to 15 inc.
	Aug. 16 to 26 inc.
	Aug. 28 to 31 inc.
	Sept. 1, 2.
Joe Rafter	Aug. 1 to 15 inc.
	Aug. 16 to 26 inc.

A meeting of the National Committee for the suppression of white pine blister was held at Albany, N. Y., November 20 and 21, 1916.

Membership of the committee was enlarged to include four from each state. In Minnesota State Forester Cox, Dr. E. M. Freeman, and F. L. Washburn were designated as representatives with the privilege of appointing a fourth. (Later: F. W. Wilhelmi of Cloquet has been appointed as fourth member. F. L. W.)

MISCELLANEOUS NOTES ON ECONOMIC WORK; ORCHARD AND SHADE TREE INSECTS, SPRAYING, TRUCK AND FIELD CROPS.

A. G. RUGGLES

A number of lectures to Farmers' Clubs, Nature Study Clubs, and other organizations were given at Glenwood, Sauk Centre, Excelsior, Faribault, Lake Elmo, West St. Paul (Men's Garden Club), St. Paul, Osseo (Minnesota Garden Flower Society), Minneapolis.

Spraying demonstrations outside of the University Farm were given at Hugo and Preston.

From time to time letters and calls over the telephone reach us of some serious damage being done to trees, field or farm crops and truck crops. If we cannot give the information from the description, whenever possible, we personally investigate the injury and give practical methods of control. About ninety of these trips have been made during the last biennium, and in some cases the trouble has been so serious that we have had to repeat our trips later and see that certain recommendations were carried out.

At Sauk Centre and Glenwood the trouble with the trees was an outbreak of Cottony Maple Scale. This meant a city problem of spraying. These cities bought spraying machines and effectually stopped the work of the insect. Potatoes at Princeton were badly attacked last year with leaf hopper and plant bugs. These insects were not killed by our ordinary methods of protection, hence we are now working on a project which we hope will ultimately give us methods of control of these forms. At New Richland the corn is being killed by wire worms under rather peculiar circumstances. We have a definite problem here to work out on the control of this insect. Many reports of this character come to the office, and by these personal investigations we are able to give considerable help, often leading to more detailed study of the insect by the members of the department.

Our specific problems for investigation at present have the following titles:

1. Insect Collection.
2. Spraying.
3. Orchard and Shade Tree Insects.
4. Field Crop Insects.
5. Truck Crop Insects.
6. Weed Insects.

Insect Collection.

This department has a fairly large collection of insects for a department of this kind. There are so many forms of insect life that it is utterly impossible for one man to know all of them. Comparing the specimens sent in with those in the collection is necessary for an up-to-date department. It is a fact, however, that unless such a collection is attended to constantly and additions made, it will rapidly deteriorate. With this in mind we are, as much as time and funds permit, adding to our collection and having experts on groups work up the newly collected material. This past year we have been fortunate in having in the city Mr. M. P. Somes, a well-known Orthopterist, who has gratuitously given a month or more of his time to naming and arranging our groups of Orthoptera and also in helping us with the collection of Coleoptera, particularly in naming specimens taken at Itasca Park. Our collections are now so large that an expert of this sort should be employed the entire time to act as curator and make collections to keep the collection usable.

Spraying.

In our spraying experiments we have demonstrated that,—

1. Arsenate of lead if properly used, is a better spray for potatoes than Paris Green.

2. In the regular orchard spraying a dormant spray of Lime Sulphur is usually not necessary.

3. Three sprayings of the orchard, if properly done, will keep the insects and diseases under control.

When arsenate of lead is to be used on potatoes, the important thing is to get it on early, before the grubs hatch from the eggs. It can be put on when the spring beetles are flying and, sticking to the leaves through the rains, the poison will be present for the young grubs to feed upon as they hatch. We have found that two sprayings during the season will keep the potato bug in check. When diseases are present, arsenate of lead will mix well with the Bordeaux Mixture, thus making an ideal spraying mixture.

A dormant spray is given primarily for scale insects, particularly the San Jose Scale. In no orchard of the state have we found this insect. We do, however, find oyster shell scale and scurfy scale. When these latter scales are found it may be necessary to use the dormant spray. It is a common belief that this dormant spray is effective against such spores of disease as scab. In our

experiments in co-operation with the Plant Pathology Division here at the University Farm we have found that this dormant spray is of no particular use against these diseases, the later sprayings being the most effective.

The three important and effective sprayings of the orchard should be given as follows:

1. As the flower buds begin to show color; in the apples when the center bud of the flower cluster begins to show pink.

2. Just after the blossom falls; in the case of apples, and when the fruit is the size of very small peas, in the case of the plum.

3. The third spraying should be given two or three weeks after the second in the apple, and in the case of plums, just as the fruit begins to show color.

The materials to use in the spray each time are,—three pounds of arsenate of lead paste or one and one-half pounds of arsenate of lead powder, one and one-fourth gallons of lime sulphur, if the specific gravity reading is 32° on the Baume scale, in fifty gallons of water. If plant lice are doing damage at the time of any of these sprayings a half pint of a 40% nicotine sulphate solution may be added to the mixture with excellent results.

Orchard and Tree Insects.

One of the most important tree insects studied critically is the oak twig girdler (*Agrilus arcuatus*), an insect not previously reported from the state. The life history of this insect has been carefully studied, and all its damage worked out in detail. This pest is a flat-headed borer, a very close relation to the oak bark borer, that is killing so many oaks in the southern half of Minnesota. The oak bark-borer works in the main trunk of the tree, killing from the trunk up. This one works from the twigs down the limbs, often meeting the work of the bark borer. The majority of the dead limbs seen on the red oak is due to the work of this little twig girdler.

The work of the insect is first noticed during August. At this time the leaves on the twigs hang dried out as if by blight. Egg shells will be found at the base of these leaves, and the hatched grubs tunneling beneath the bark of the twig, cut off the food supply to the leaf. These grubs or larvae burrow on down the stem sometimes beneath the bark, sometimes in the center of the twig, and in July of the second year have reached their full growth. Just beneath the bark in the wood of the limb, often six or eight feet from its entrance burrow, it pupates. The last of July and the first of

August the small metallic beetles are found flying and laying eggs at the base of buds.

Control. The only practical method of control is to keep all dead and dying limbs trimmed from the trees. Although the greatest damage seems to be to the red oaks we have found the eggs and larvae of this insect in other species, such as bur and white oaks. The dead limbs on any oak, therefore, are open to suspicion and should be pruned whenever seen and the cuttings burned.

A detailed report on this insect is being prepared for publication.

Field Crop Insects.*

In our study of field crop insects special attention has been given to the insects of corn, clover and wheat. The insect of corn which is being studied is the **Corn Ear Worm.** Our studies on this insect have just begun, but indications are that the entire life cycle of the insect is not passed within the infested locality and hence the control measures usually recommended are not applicable to our conditions in Minnesota.

The **Clover Seed Chalcis** which affects the seed has been studied for a period of years and has now been completed. We have found many interesting things in the life history of the insect, and are able to make definite recommendations for its control. The infestation of clover seed varies from as high as 40% in 1910 to as low as 4% in 1912. The average amount of seed claimed by these insects is probably at least 25%. It breeds freely in red clover, both medium and mammoth and in alfalfa. It has been taken in Crimson clover but apparently does not breed in white clover and alsike.

Control. Cutting the first crop of clover for hay while the heads are green or pink; or pasturing the clover until June 15th or 20th; or clipping it back in May, allowing in each case the second crop to grow for seed, will prevent loss from this insect. Volunteer clover and first year clover should be kept from blooming as this would allow the insects to breed where the cutting or pasturing as outlined starves the pest into submission.

The **Wheat Stem Maggot** is the important insect of wheat being studied at the present time. A considerable amount of damage is done to wheat, rye, barley, corn and bluegrass every year by this insect; often as high as 25% in parts of neighboring states.

*Mr. Warren Williamson is carrying on the experiments with these insects.

At present we can suggest only general methods of control, such as,—

1. Stacking the grain and threshing from the stack. This would prevent the escape of all the flies, which naturally emerge in the fall, except those emerging from the outer layers of the stack.

2. Trap crops may be used to attract the insect and later destroyed.

3. Plowing under volunteer grain after harvest and keeping wild grasess in check by clean cultivation.

Where fall wheat is sown, the sowing should be done as late as possible in the fall, which is also a good control measure for Hessian fly.

Small Fruit Insects.*

Two important insects of small fruits studied have been the **Strawberry Weevil** and the **Raspberry fruit** worm.

The Strawberry Weevil damages the blossoms and prevents the formation of fruit. The insect itself is very small, only about 1-10 of an inch in length, yet is capable of destroying 20 to 90% of the buds in a strawberry field. We have found that in Minnesota the weevils hibernate entirely within the strawberry field under the straw and leaves in the old bed. When the plants blossom in the spring the insects are present ready to do the damage.

Control. Old beds serve as excellent breeding places for these insects and hence when the weevils are present the **one-crop** system is recommended. If two crops are to be obtained, the field should be thoroughly cleaned of weeds after the fruit harvest and the bed should be burned over. In other words, make a new bed after every harvest. Spraying as recommended by other experimental stations has given poor results in Minnesota.

The Raspberry fruit worm is recognized as the small, brownish white worm that one often finds clinging to the core of the berry. Berries infested with this grub are smaller and discolored, and make necessary the picking over of all raspberries intended for the table. The weevils pass the winter as pupae in the soil near the base of the plants. In the spring when the young plants are about six inches high the insects leave the ground as beetles and feed on the tender leaves and buds. Often 10 to 15 per cent are thus injured. The King and the Miller varieties are most severely attacked, while Cuthberts and Black Caps are more or less immune.

*Mr. Simon Marcovitch has done the investigational work with these and with weed insects.

Control. Cultivation as late in the fall and as early in the spring as practicable close to the stems of the berries will disturb their hibernating quarters, and by direct injury or exposing them to changes of winter temperatures many will be killed. Spraying the canes in the spring, when the young plants are about six inches high, with arsenate of lead, two pounds of the powder to fifty gallons of water will be very effective. These precautions, with no neglected canes in the immediate vicinity will control the insect.

Weed Insects.

In our studies up to this time about twenty of our common weeds have yielded thirty different species of insects. Some of these insects have been so abundant that the weed was not allowed to spread in that locality. This is a benefit that such insects may bestow. On the other hand, some weeds harbor insects which in turn attack our cultivated crops. Sometimes again, a weed insect may appear quite harmless except to the weed, but if a particular crop perhaps of some closely related cultivated form were grown near it, the insect may attack the crop in preference. Such being the case, it is very important to know as much as possible concerning weed insects and thus be prepared for what the future may bring.

NOTES ON PARASITIC AND HOUSEHOLD INSECTS

C. W. HOWARD

The housefly is the insect of this group which has attracted perhaps the widest attention. Many observations have been made locally upon its life history and habits, but special attention has been given to two points, its control and the method by which it passes the winter. The latter point is one of the few regarding the housefly which has not yet been satisfactorily solved. Our investigations upon this subject will be completed the coming spring and the results published then. Work on control has been confined to conditions met with in small towns and on farms. Fly control in cities has been reduced to a comparatively easy routine system, but in rural districts it is not always so convenient to put control measures into operation. In many places it is not possible to carry out the measures recommended in any way at all adequate. Having this in mind and also the part which the fly plays in the transmission of human diseases, particularly of intestinal diseases, we have placed considerable emphasis on the improvement of sanitary conditions upon the farm, thus preventing the flies from gaining access to material which carries disease organisms. A leaflet has been prepared outlining our recommendations and this has been widely distributed, two editions having been already exhausted. Feeling, however, that an optical demonstration would be more effective, a large model of a farmstead, 10x15 feet, was constructed, showing all of the farm buildings and the various methods for fly destruction, from the hauling out of manure daily to spreading it thinly upon the field where it will dry quickly, to the maggot trap and manure closet or bin. A complete model of a septic tank connected with the bath room and kitchen in the house, showed how to dispose of household sewage so that flies could not get to it. A fly-proof milk house, with screened enclosure for airing the milk buckets, and fly-proof, sanitary earth closet completed the exhibit. These models have been exhibited twice at the State Fair, and at three county fairs, Wheaton, Brown's Valley and Winona. It has attracted so much interest that we plan to exhibit it at other county fairs next fall.

The biting stable fly, a close relative of the house fly, but a blood-sucking insect, is a serious pest of stock in Minnesota. Some time has been given to studying it under local conditions. Its life history is in general like that of the house fly, breeding principally in stable manure. Control measures are similar. Our next search will be for a good repellant which may be applied to animals to prevent its attack when breeding cannot be controlled. At present there is no material on the market for this purpose, which is sufficiently cheap, or effective when applied. The relation of this insect to swamp-fever of horses has also been under investigation, but will be reported upon elsewhere, as the work was done under a different fund.

Horse flies are, next to mosquitoes, the worst pest of stock in the northern part of Minnesota. Funds have not made it possible for us to carry on as intensive a study of these insects as they deserve. In places where farmers are trying to build up dairy farms, the presence of these flies has reduced the milk supply as much as 66 per cent in two weeks and in three nearly 100 per cent. There is also a very large, but not easily recognized, insidious loss to animals from the annoyance caused by these flies and the resulting nervous reaction, as well as by the loss of blood, for they are possessed of very large, piercing mouth parts and blood may flow from the wound for a long time after they have filled themselves and flown away. There is only one generation each year, the adults appearing in spring and early summer in enormous numbers, disappearing in about four weeks. Five species are common in the northern part of the state. These seem to breed in low-lying, wet land surrounding swamps and muskegs, it requiring ten to eleven months for the growth of the grub in these wet places. Probably more extensive cultivation and drainage will reduce the numbers of the flies by removing their breeding places, but further studies of these flies must be made as soon as funds are available, before authoritative recommendations can be made. The connection of these flies with swamp-fever has also been investigated.

There is a growing demand for more information upon mosquitoes, mostly from the cities, but also from farming districts. While a quite complete survey for species found in Minnesota was made several years ago, our knowledge of these insects has increased very much in recent years and a new survey has been begun, not only to ascertain the kinds of mosquitoes occurring in the state, but also their habits and life histories. This survey is now well under

way; a list is published elsewhere in this report. The opportunity was also given in 1916 to conduct an anti-mosquito campaign for the Minneapolis Real Estate Board, which proved very successful and is resulting in a more extensive campaign of the same sort planned for the summer of 1917, coupled with an anti-fly campaign. This information about mosquitoes will not be of use to cities alone, for they are one of the serious pests of stock, although often overlooked as such. In 1915 they were so numerous as to be one of the principal causes for a decrease in the milk flow of dairy cattle.

An important pest of the household is the cockroach. So far no really satisfactory, quick-working remedy which could be used by any housewife has been suggested. We are now at work perfecting a remedy which promises to be quickly and completely effective.

Several other insects have come under our attention, but owing to lack of assistance and funds it has not been possible to take them up as definite problems for investigation, such as our local ticks, sand flies (Simuliidae), weevils found in grain and dried cereals, carpet beetles, clothes-moths, lice upon cattle, etc.

THE WHITE MARKED TUSSOCK MOTH

A. G. RUGGLES

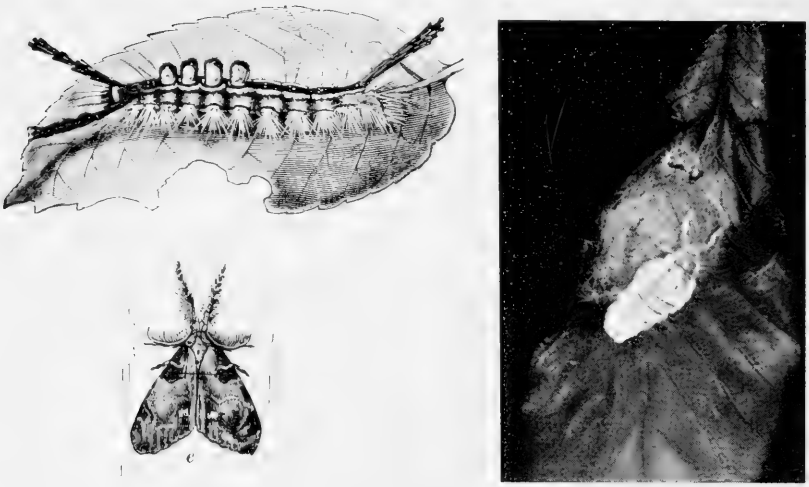


Fig. 14. A full grown caterpillar; male moth; wingless female moth just emerged from the cocoon and beginning to lay eggs.

In certain years the caterpillars or larvae of this insect are probably the most abundant of the leaf eating forms found in the state. Basswoods, elms and maples are the principal trees attacked. The past season has been favorable for the development of these insects, and in many places throughout the state the egg masses may be seen in large numbers on the trees mentioned. Unless something is done the caterpillars will do a tremendous amount of injury this year.

This insect is primarily a shade tree pest, although if not controlled it will work on trees in the orchard. The control of this insect is usually a city problem, which means the cooperation of individuals and the city government. With these things in mind, some knowledge on the habits and forms of the insect will be valuable in controlling it.

LARVAE.

The larvae are the most beautiful of our caterpillars. The head is coral red, with a pair of long black plumes projecting over it. At the opposite end of the body is a single black plume. On the back are four whitish brush-like tufts looking like miniature

paint brushes, and just behind these are two red tubercles. The young caterpillars are hairy and only about 1/6 of an inch in length. They often spin a silken thread by means of which they lower themselves upon a sudden jarring of the tree. Being very light they are readily blown at this time to neighboring trees, hence spreading the infection. These young caterpillars feed only on the epidermis of the leaf, but as they get older more and more of the leaf is eaten until when full grown all the leaf is eaten but the midrib and perhaps a few of the larger veins. It takes five to six weeks for the caterpillars or larvae to mature. At the end of this stage they begin to wander over the tree and from tree to tree looking for a place suitable for pupation. When found the larvae spin cocoons in which many of the hairs of the body are interwoven. About a fortnight is spent as pupae in these cocoons.

ADULTS.

About the first part of July the adults make their appearance. The females are wingless creatures and rarely ever leave the cocoons until the eggs are deposited, after which they die. The males are beautiful little moths with delicate feathery antennae and hairy legs. The wings are marked with several shades of gray and have a wing expanse of nearly one inch.

EGGS.

The eggs are laid on the discarded cocoons of the female in masses each containing from one hundred to five hundred eggs. A frothy white secretion covers and binds the eggs in a solid mass.

HIBERNATION.

The eggs in these conspicuous white masses remain over winter. About the last of May and the first of June the eggs hatch and the young begin feeding on the leaves.

CONTROL.

Fortunately there are a large number of predacious and parasitic insects that prey upon the Tussock Moth and often keep it in check. Fungous and bacterial diseases also play a part. In some years, however, conditions are not favorable for the development of these forms and the Tussock caterpillars become abundant and do considerable damage. Of the hundreds of egg masses that we have examined at the present time, the great majority of the eggs appear to be perfectly healthy, and unless these enemies are very abundant during the early stages of the caterpillars great damage may be looked for in June, 1917.

The best remedy of all is to collect and destroy during the fall, winter and early spring the egg masses. These egg masses are easily seen when the leaves are off the trees and can then readily be scraped off and destroyed. City foresters, in cities where these luxuries are available, have men go over all the trees under their control and scrape off these masses with long handled hoes made for the purpose. The egg masses are collected in pails and destroyed at some central station. The owner of private property having his trees infested should have them treated in the same way.

When city authorities have no jurisdiction for this work, public opinion should be aroused and all cooperate to find a means of collecting and destroying these egg masses. Many cities have secured the help of school children, paying them a certain amount for every quart, or for a certain number of egg masses. This action has often proved very successful. Egg masses treated with creosote oil and turpentine has given good results in killing the eggs. If the egg masses cannot be collected this treatment should be tried.

When the eggs are allowed to hatch, non-infested trees, if the limbs do not intertwine, may be protected by banding the trees with some material like cotton batting or tree tanglefoot that will hold the caterpillars until they can be destroyed. Bands of any kind must be watched constantly during the period otherwise they will be of no value. If the tree affected is not too large it may be jarred, which will cause the little "worms" to descend on their silken cords. Not being able to climb back on the silk, the bands on the tree trunk will then prevent their ascent.

Spraying large trees with arsenicals is more or less impractical, and is very expensive. If the tree is not too large, an arsenical poison like arsenate of lead or paris green may be used at the rate of three pounds of arsenate of lead powder, or one and one-half pounds of Paris green to fifty gallons of water. The smaller the caterpillar when the spraying is done the better will be the results from spraying.

COOPERATION.

In controlling the Tussock Moth it is necessary, therefore, to cooperate with your neighbor in—

1. Destroying the egg masses, either by gathering them or wetting them with creosote,

2. Banding the trees to prevent the ascent of the fallen larvae, or,

3. To spray the infested trees.

Cooperation in any method of control is essential to success.

DISTRIBUTION OF FISH TO MINNESOTA FARMERS

F. L. WASHBURN

The State Entomologist's office is frequently required to undertake economic work, which has nothing to do with insects. This is practically the case in almost every state where the office exists. In the present instance we refer to the distribution of fish to Minnesota farmers in 1916.

The Secretary of the Department of Commerce expressed to the Director of the Experiment Station a desire on his part to assist farmers throughout the country by granting them upon proper representation of their needs and conditions on their farms, consignments of fish suitable for these conditions. The Director allotted this work to the State Entomologist, and this proposition on the part of the Secretary of Commerce was made public throughout the state. Many applications for fish were received by this office. To these applicants blank federal applications were sent and additional questions compiled by the writer. Careful consideration of these answers and consultation in regard to each applicant with our State Fish Commissioner resulted where such was possible of an endorsement of the application on the part of the State Entomologist and the Director of the Station. These endorsed requests were forwarded to the Department of Commerce at Washington, and the Bureau of Fisheries as far as they were able distributed fish to the successful applicants.

Some approved applications could not be taken care of this year and are now on file at Washington. We append herewith list of Minnesota citizens furnished with fish under the above conditions, giving the number and variety of fish and the date shipped, also list of citizens whose applications are at present on file at Washington.

APPLICATIONS FILLED.

A. G. Anderson, R. F. D. No. 2, Long Prairie, Minn., 425 black bass. Sept. 6, 1916.

Ewald Baufeldt, R. F. D. No. 3, Elk River, Minn., 600 sunfish (bream). Sept 1, 1916.

H. D. Blanding, Detroit, Minn., 425 black bass. Sept. 12, 1916.

W. P. Cockey, for Baltimore Investment Co., Piedmont Apartments, St. Paul, Minn., 600 sunfish (bream). Sept. 19, 1916.

F. M. Green, Menahga, Minn., 340 black bass. Sept. 6, 1916.

Vitalis Johnson, R. F. D. No. 2, Fertile, Minn., 340 black bass. Sept. 12, 1916.

C. H. Meyer, R. F. D. No. 4, Detroit, Minn., 450 sunfish (bream). Sept. 12, 1916.

C. E. Olson, Underwood, Minn., 340 black bass. Sept. 19, 1916.

Arthur Peterson, R. F. D. No. 1, Box 15, North Branch, Minn., 150 crappies. Sept. 27, 1916.

Paul Schafer, Morton, Minn., 150 sunfish (bream). Nov. 17, 1916.

Anton Schill, R. F. D. No. 3, St. Cloud, Minn., 255 black bass. Sept. 6, 1916. Also the following received just after the close of the biennial period.

L. E. Russell, Tamarack, Minn., 100 crappies. Dec. 5, 1916.

Albert Breese, Little Falls, Minn., 100 crappies. Dec. 5, 1916.

T. E. Gangstee, Currie, Minn., 300 catfish. Dec. 5, 1916.

Philip Lander, Adrian, Minn., 200 sunfish (bream). Dec. 5, 1916.

APPLICATIONS ON FILE (UNFILLED).

George Estrem, Atwater, Minn., pike, perch.
N. J. Fabian, St. Paul Park, Minn., rainbow trout.
W. C. Lounsberry, Larsmont, Minn., brook trout.
Edward Peterson, Crookston, Minn., pike, perch.
Louis A. Posz, Winona, Minn., brook trout.
Earl Simpson, Winona, Minn., brook trout.
Mrs. Lena Thayer, Lake Lena, Minn., pike, perch.

We are assured by the Federal Bureau having this in charge that the above unfilled applications will be considered in 1917.

THE COMMON MOSQUITOES OF MINNESOTA

C. W. HOWARD

There is a growing demand in Minnesota for information about mosquitoes which will aid in work to be carried out for their control. During the past four years collections and observations have been made whenever possible, and particularly so during the summer of 1916 in connection with the Minneapolis Mosquito Campaign. Reference books on mosquitoes are not easily accessible to those not in close touch with a large library and the study of mosquitoes is so new that the multiplicity of names and of species would probably confuse the layman. For these reasons, a preliminary account of the commonest and most important Minnesota mosquitoes may be of use to those interested in anti-mosquito work.

In this account it will be taken for granted that the reader is familiar with the fundamental facts of mosquito life. If not, Bulletin No. 55 of the Farmer's Library Series of the Minnesota Experiment Station should be secured, or the Tenth Annual Report of the Minnesota State Entomologist for 1905.

There have been twenty species of mosquitoes recorded so far from this state, only eleven of which seem to be common. Further collections will probably produce several more and to the list might be added one or two species which are non-bloodsucking and are not considered as true mosquitoes, in spite of their close similarity in appearance.

The habits of each species of mosquitoes vary and to control it efficiently these must be known. It is necessary to be able to recognize common species, and for this one must be somewhat familiar with the grosser morphology. It is also often necessary to determine the species of a mosquito while it is still in the larva stage without waiting for the adult to emerge. The accompanying diagrams of an adult mosquito and a larval mosquito will give these points much better than by a written description.

No mention will be made of the pupa stage. It is so similar in all of the mosquitoes as to offer no easy means of identification of species. Whenever pupae are found, larvae will also be present and can be collected as easily.

In studying mosquitoes the larvae can be dipped up with small nets made of tea strainers over which a piece of fine cheese cloth has been sewn. From this they should be at once transferred to a

pail of water for transportation to the laboratory, where they can be isolated in tubes of water and each one or each kind reared separately to the adult stage. If it is not desired to take them into the laboratory for study, they can be dropped into eighty per cent alcohol, in which they will remain in good condition for study for a long period. Specimens can be removed, whenever desired, and placed on a slide for study under the microscope, or they can be

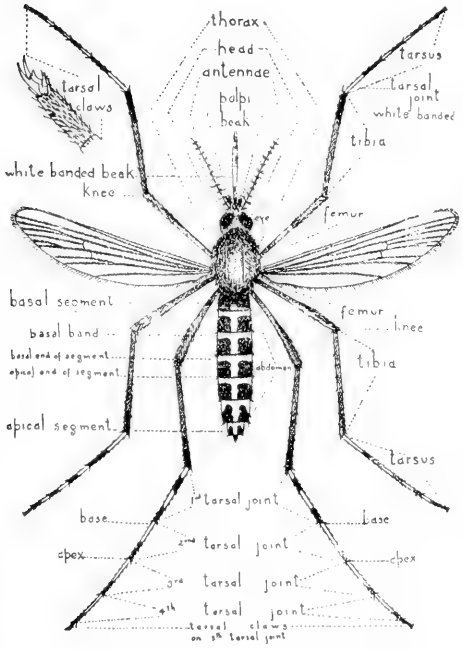


Fig. 15—Adult mosquito with parts named (from Smith).

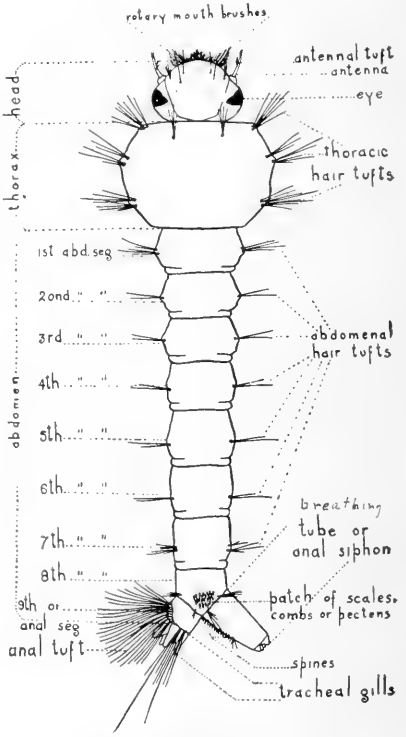


Fig. 16—Mosquito larva with parts named (from Smith).

cleared in xylol and mounted in balsam on a microscope slide for permanent study. The adults are in most perfect condition for study when reared from the larvae in the laboratory and killed at once. Mosquitoes captured in the open are often so mutilated as to be unrecognizable. As soon as the mosquito has emerged, place it in a cyanide bottle and leave it there until dead. When dead empty it onto a smooth surface, such as a sheet of glazed paper. Never touch the specimen with the fingers and even if forceps are used great care must be exercised not to rub off scales or otherwise

injure the specimen. Most mosquitoes are too small for a serviceable insect pin to be used in pinning. It is best to use small blocks of pith or cork, about twice as long as wide. Through one end thrust an extremely fine pin, known as a "minutien pin," and impale the mosquito either through the thorax from front to back or from side to side. Through the other end of the block force a large insect pin. The cork should project to the left of this large pin and the mosquito should have the head forward and legs projecting toward the left. On the large pin place a small label, bearing the place and date of collection and other important information desired. The specimens can then be stored in a cork-lined, tight-fitting insect box.

Minnesota mosquitoes may be grouped roughly into (1) those which breed in artificial collections of water in the vicinity of human habitations or those which we may call domestic mosquitoes, and (2) those which breed in natural collections of water either permanent or temporary, open or in woodlands. These restrictions are not entirely binding, for the domestic mosquitoes may, under stress of circumstances, breed in swamps and the second group occasionally in artificial collections of water. The former group includes *Culex pipiens* and *Culex restuans*. The rest of our mosquitoes belong to the second group.

We have several of the peculiar northern forms which produce only one generation in the spring, and whose eggs lie over winter at the bottom of swamps or in wet or damp places where snow water will collect the following spring, providing a suitable medium for the growth of the larvae. These large spring broods may fly considerable distances from their breeding places. These facts make the control of our mosquito pest a peculiarly difficult one.

In cities control measures must be directed first against the domestic forms. This means prevention of breeding in rain barrels, rubbish heaps, sewer catch basins, roof drains and any other place where water may collect and remain for a couple of weeks. This can be accomplished by covering the water receptacles with netting or oil, or by cleaning up rubbish heaps so that old tins will not hold water, placing oil in sewer openings, keeping roof drains cleaned out, etc. Measures against the swamp-breeding forms must be carried out at the same time, must extend well afield and must be carried out at the proper time to reach the early spring breeding forms as well as the late forms. Where marshes cannot be filled or drained, they must be sprayed with kerosene or petroleum oil at frequent intervals. The first spraying must be carried out early

in the spring to get the early species. Later a spraying as often as once in two weeks may be necessary. Woodland pool mosquitoes may be controlled in the same way, although not many of them will annoy man unless dwellings are close to the edge of the woodland.

Key for Determining Adult Mosquitoes.

The following key is based as far as possible on grosser, easily recognized characters, recognition characters:

A. Wings spotted.
  B. Two dark spots on front margin of wing; last vein white with end black.
    Anopheles punctipennis
  BB. Wings with four distinct brown spots; last vein all brown.
    Anopheles quadrimaculatus

AA. Wings not spotted.
  B. Tarsi white or yellowish banded.
    C. Beak with a wide white band near the middle of its length.
      D. A large brown mosquito, with brown and white scales producing a mottled appearance. Bands on base of tarsal segments.
        Mansonia perturbans
      DD. A smaller, greyish mosquito. Tarsal bands on both base and tip of tarsal segments.
        Culex tarsalis
    CC. Beak unbanded.
      D. Joints of tarsi bearing white band only at the base of each segment.
        E. A small dark species; white bands at the base of the abdominal segments strongly constricted on the median line; wings lightly scaled.
          Aedes sylvestris
        EE. A large species; wings thickly scaled; anterior edge black; thorax with a broad dark median stripe.
          Aedes abfitchii
      DD. Joints of tarsi with a white band at both base and tip of each segment; last joint of hind tarsus usually entirely white.
        Aedes canadensis
  BB. Tarsi unbanded.
    C. Thorax striped, or spotted.
      D. Thorax with two white longitudinal stripes.
        Aedes trivittatus
      DD. Two small white dots, one on each side of median line, and a U-shaped mark at the base. (These may be lacking.)
        Culex restuans
      DDD. Thorax golden scaled with broad dark brown band in middle.
        Aedes auroides
    CC. Thorax unmarked.
      D. Small dark brown species; abdominal bands wider in middle than at sides except on seventh segment which is wider at the sides; legs and beak black.
        Aedes fuscus
      DD. Medium sized brownish species; bands of abdominal segments of moderate width.
        Culex pipiens

TABLE TO DETERMINE MOSQUITO LARVAE

A. No breathing tube on eighth abdominal segment. Lie parallel to surface of water.

Anopheles punctipennis
Anopheles quadrimaculatus

AA. Breathing tube present on eighth abdominal segment.

B. Scales on eighth abdominal segment not more than sixteen in number.

C. Breathing tube three times as long as broad or longer.

D. Larva fairly large, breathing tube stout.

E. Twelve elongate scales in a single row on eighth abdominal segment. Twelve to sixteen spines on breathing tube, each with one moderate tooth, and sometimes a few smaller ones below.

Aedes fuscus

EE. Ten to fifteen scales in a partly double row tapering apically; fourteen to eighteen spines on breathing tube, simple or with two or three teeth.

Aedes sylvestris

DD. Larvae small, about one-fourth of an inch long; breathing tube slender, at least five times as long as broad.

Aedes aurioides

CC. Breathing tube very short and pointed, fitted to puncture plant roots to which larva remains attached.

Mansonia perturbans

BB. Scales twenty or more in number, forming a large patch.

C. Breathing tube short, not more than twice as long as broad; scales on eighth abdominal segment fourteen to twenty-two in number, with stout apical and slender lateral spines with two or three serrations, sometimes simple.

Aedes trivittatus

CC. Breathing tube moderate, two and one-half to three and one-half times as long as broad; scales twenty-five to fifty in number with small apical and smaller lateral spines; sixteen to twenty-four spines on breathing tube with four or five serrations on basal half.

Aedes canadensis

CCC. Breathing tube not less than four times as long as broad.

D. Breathing tube of moderate length, sides a little inflated.

E. Tracheal gills moderately long; tuft on antennae at or before middle of length.

Culex pipiens

EE. Tracheal gills rather long; tuft on antennae beyond the middle of the length.

Culex restuans

DD. Breathing tube very long, five times as long as widest diameter.

Aedes abfitchii

Culex pipiens Linn—The House Mosquito.

This extremely common mosquito was probably introduced into North America from Europe and is always closely associated with man, being seldom found far from his habitation. It is a city form, being more often represented in rural districts by its close relative,

Culex restuans. A flight of a few hundred yards from its breeding place is the usual extent of its wanderings, but it is now thought that it may slowly find its way from one to three miles from its place of origin, when an area becomes overstocked with individuals.

It may be easily recognized by its yellowish-brown color, and the absence of all bandings or markings except for a narrow white band on the base of each abdominal segment. In structure it is slender and of only medium size, often being so small as to be able to penetrate window screening of the size mesh usually employed.

The female spends the winter hidden away in warm cellars, stables and storehouses. During warm days in winter and early

Fig. 17—Good breeding places for the household mosquito.

spring it may emerge and will take a meal of blood if opportunity offers. As soon as the season becomes sufficiently warm it emerges from hibernation and is ready for oviposition. The eggs are laid during the latter half of the night in small, boat-shaped rafts which float on the surface of the water and resemble, superficially, small masses of soot. Each raft contains from fifty to four hundred eggs. These eggs hatch in twenty-four hours if the weather is warm, the larvae dropping into the water below.

Culex pipiens nearly always chooses artificial collections of water on which to place her eggs; such as rain barrels, tin cans on dumps holding water, sewer catch basins, clogged roof drains and

even flower vases in a house, but will also oviposit in ground pools if the water is sufficiently polluted. They prefer water which is slightly or excessively foul, but we have several times taken the larvae in water collected in cattle foot prints; pools on the margin of ponds and similar places. The size of the collection of water is not essential, the prime requisite being that it remain permanent long enough for the larvae to mature.

The wigglers will reach full growth in from six to seven days if the temperature and food supply in the water is suitable. The pupa stage lasts for from one to three days, the entire life cycle may, therefore, be passed in twelve days under optimum conditions. Brood follows brood until frost appears.

As the season advances the numbers increase until a locality may be completely overrun with them. Rainfall is not favorable to their development for, under such conditions, eggs and larvae will be washed out and destroyed. Extremely dry weather also is unfavorable, drying out most of the breeding places, except in such places as sewers, where water collects and lack of rain prevents their being washed out.

The larva is pale yellowish in color and slender with the anal siphon at least four times as long as wide and the sides slightly swollen. The antennae rise from the sides of the anterior part of the head and have the hair tufts beyond the middle point.

The scales on the eighth abdomal segment are thirty-five to forty in number, are well separated and form a low triangular patch and each scale has a long fringe on the sides. The breathing tube has twelve to fifteen spines in each row, each spine with three or four long teeth.

This species, while it does not occur in the extreme north of the American continent, is probably found in every part of Minnesota where conditions favorable to its development exist. We have taken it in the following places:

Adults.

University Farm—23 to 28 of June, 1916. Near a pond.
St. Paul—24th June, 1916.
Minneapolis—June 26th, 1916.
Minneapolis—July 15, 1916. Near a marsh.

Larvae.

University Farm—12 May, 1914—in edges of a marsh.

St. Paul—27 May, 1914—in pond polluted with sewage.

University Farm—13 August, 1913—in water in cattle foot prints.

University Farm—18 August, 1916—tin buckets.

St. Paul—18 August, 1916—rain barrels and sewer catch basins.

Minneapolis—26 August, 1913—in rain barrel and edge of polluted swamp.

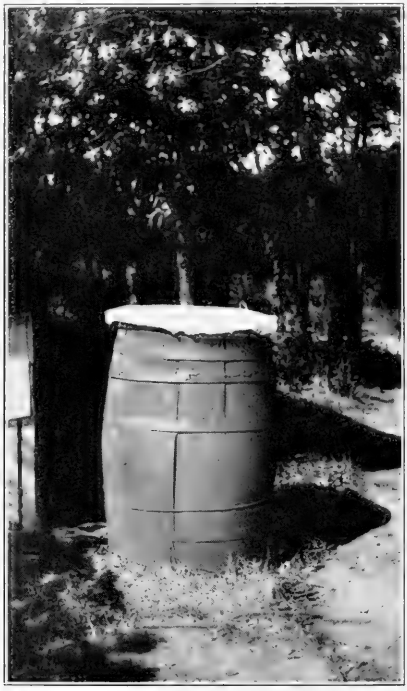


Fig. 18—One way in which to keep mosquitos from breeding in rain barrels.

Specimens of adults are also in the department collection bearing the dates May 20, 1896, June 12, 1896, July 6, 1896, and November 5, 1896. No mention is made of locality from which they were taken, but it was probably in the vicinity of the Twin Cities.

Culex restuans Theob—The White-Dotted Mosquito.

This mosquito is so closely associated with and so closely resembles *Culex pipiens* as to be easily mistaken for it. In coloration it is slightly darker. Under a hand lense two small round

white dots can be seen, one on each side of the thorax, near the middle of its length. Immediately behind these is a U-shaped white line. These markings are very frequently not present, making it more difficult to separate it from *Culex pipiens*. Most references to the household mosquito in the past have probably included both of these species.

The life history and habits are very similar to those of *Culex pipiens*. The adults hibernate over the winter and place their eggs in rafts on the water the following spring. Generation succeeds generation through the summer. Artificial collections of water, small collections on the ground, holes in trees, etc., are chosen for breeding places. As a rule they prefer cleaner water than does *Culex pipiens*. In most of our collections we have found the wrigglers of these two species mingled except in localities distant from large centers of population where *Culex restuans* was the only species found in such places as rain barrels. The adults do not enter houses quite as readily as *Culex pipiens*, but bite with the same voracity.

The larvae can be distinguished from the larvae of *Culex pipiens* by the fact that the tuft of hairs on the antennae is at a point below the middle. There are a few more spines on the breathing tube and the tracheal gills are longer and not so pointed as in *Culex pipiens*.

We have taken *Culex restuans* in Minnesota, as follows:

Adults.

University Farm—June 23, 1916.
St. Paul—June 24, 1916.

Larvae.

University Farm—August 13, 1916—in water in cattle foot prints.

Monticello—August 21, 1916—in rain barrel on farmstead.

Minneapolis—August 26, 1913—in rain barrels.

In the departmental collections are the following records as to date of capture, but no locality is given:

June 5, 1896; June 12, 1896; July 6, 1896.

Aedes sylvestris Theob—The Swamp Mosquito.

This mosquito and *Culex pipiens* are the commonest mosquitoes in Southern Minnesota. In the more swampy, unsettled northern portions of the state other species are more abundant, at least during

the early part of the summer. But this form seems to remain well represented until autumn, a killing frost being necessary to bring about their disappearance.

It is a medium sized, dark brown or blackish mosquito, having a prominent white band at the base of each tarsal segment. The abdominal segments also bear white basal bands, which are so strongly constricted in the middle as to appear divided into two.

They appear very early in the season. In the vicinity of the Twin Cities they, with *Aedes canadensis*, are the first mosquitoes to appear in the spring. Larvae may be collected in early May and adults from late May and early June to early October. They frequent the vicinity of houses, but seldom enter. They are, however, vicious and persistent biters.

The life history is as follows: The winter is passed in the egg stage, the eggs lying at the bottom of pools of water. These eggs hatch in the early spring, as soon as snow and ice are melted, the resulting larvae producing the early invasion of mosquitoes, which appears late in May or early in June. Brood succeeds brood throughout the summer and early autumn as rapidly as conditions allow. The eggs seem to hatch unevenly so that the succession of broods is not well marked.

They prefer open pools and swamps for oviposition, whether of a permanent or temporary nature. Occasionally they are found in woodland pools. They will not breed in water polluted with sewage. The name of "Swamp Mosquito," which has been given it, is very applicable, as they are our commonest swamp-breeding form.

Unlike the common domestic form, *Culex pipiens*, this mosquito can travel long distances from its breeding places, as far as five miles having been recorded, but it probably seldom goes more than half a mile to a mile.

The larva is of moderate size, variable in color, usually with dark spots on the head. The tuft on the antenna is one-third of the distance from the base. The breathing tube is one and one-half to three times as long as wide. The spines on the siphon consist of fourteen to eighteen in each row and may have two to three heavy teeth near the base. The scales on the eighth abdominal segment are thorn-shaped, ten to fifteen in number, well separated and arranged in a double row. A very short, fine fringe of hairs can be seen on the edges.

This species occurs from New Jersey to British Columbia and will probably be found all over Minnesota. We have taken it at the following places:

Adults.

St. Paul and Minneapolis—June 26, 1916.
Minneapolis—July 15, 1916—near a swamp.
University Farm—July 23, 1916.
Fergus Falls—August 21, 1912.
Minneapolis—September 5, 1916.
Crookston—September 27, 1912.
University Farm—October 5, 1916—in street car.

Fig. 19—An ideal place for the production of swamp mosquitos such as *Aedes canadensis*

Larvae.

University Farm—May 12, 1914, and July 2, 1914—in lagoon and in cattle footprints, near lagoon, holding water.

In the department collection are specimens taken at Crookston, August 13, 1896, and at St. Paul, May 19, 1896, August 25, 1896, September 13, 1896, and September 29, 1900.

Aedes canadensis Theob—Woodland Pool Mosquito.

This mosquito resembles *Aedes sylvestris* except that it has a white band at both base and tip of each tarsal segment, making these tarsal bands apparently of great width. The distal segment of the hind tarsi is entirely white. It prefers woodland pools for its larvae, but they may also be found in open ground pools with the larvae of *Aedes sylvestris*.

Aedes canadensis appears early in the spring in company with *Aedes sylvestris*, and being nearly as abundant, makes the spring invasion of mosquitoes very large. By the end of July they have nearly disappeared.

Like *Aedes sylvestris*, the winter is passed in the egg stage. The eggs hatch very early in the spring, but not regularly. Headlee states that in New Jersey several generations follow the first, but that the eggs of each brood do not all hatch, a successively greater number lying over winter to hatch the next spring. For this reason each brood of adults is successively smaller. Howard, Dyar and Knab state that all of the eggs hatch in the spring if they are in a favorable place, giving one single brood each year. The eggs apparently require freezing before being able to hatch. Where there appear what are apparently later broods, they are thought to be caused by heavy rains washing the eggs from dry places, down into pools of water, or raising the level of the pools so as to cover the eggs. Which of these statements as to the life history is correct we are not in a position to say at this time.

The larva is of medium size; the head is usually dark colored; the breathing tube is two and one-half to three and one-half times as long as broad; the spines on the breathing tube, numbering 16 to 24, bear several short teeth on the lower third or half of their length. The scales on the eighth abdominal segment are twenty-five to fifty in number, arranged in an irregular group, each scale having a heavy, sharp spine at the top and several heavy hairs on the sides.

We have taken this species in our collections only about the Twin Cities, but there seems little doubt that it is found more widely through the state, probably throughout the entire state. It has been reported through the northern United States and Canada from New Jersey, New Hampshire and Ontario to Montana and British Columbia.

Our records are:

Adults.

Minneapolis—June 7, 1914; June 26, 1916; July 15, 1916.
University Farm—June 23, 1916.

Larvae.

University Farm—May 12, 1914, and July 2, 1914. In a lagoon and in cattle footprints about the margins.

Aedes fuscus O. S.—The Little Smoky Mosquito.

This is a small, dark brown mosquito with black legs and beak. The femora, however, are lined on the inner sides with lighter color. The abdominal segments bear narrow white basal bands, while on the thorax are sometimes seen three faintly marked dark longitudinal lines.

The life history is probably the same as with *Aedes canadensis,* the eggs hatching in early spring and only one brood during the year. What appear to be later broods probably are due to heavy rains causing held-over eggs to hatch. In the northern part of

Fig. 20—Some of the early spring breeding mosquitos come from such water puddles as these.

Minnesota they and their larvae are extremely abundant in the early spring. It is said that they will not attack man, but such has not been our experience. It does not seem to travel far from its breeding place.

The larva resembles that of *Aedes canadensis* and *Aedes sylvestris,* but is more slender; the color is light to dark gray; the antennae bear the tuft well below the middle of their length. The

scales on the eighth abdominal segment number twelve, in an irregular row, each scale being elongate, with fine hairs on the edges and no apical spine. The breathing tube is three to four times as long as broad; each row of spines on the tube consisting of twelve to sixteen spines, each with one large tooth and one to four small ones below it, near the base of the spine. This is one of the commonest and most abundant of the early spring mosquitoes in northern Minnesota.

Adults have been taken at Clear River, Roseau County, Minnesota, 15 June, 1914.

Aedes abfitchii Felt and Young—The Large Meadow Mosquito.

This is a large, light to dark brown mosquito, found in the spring and early summer. The wings are heavily scaled, the anterior margin being nearly black with slight flecking with white scales. The thorax is covered with golden brown scales, with a narrow line of light, cream-colored scales on each side and close to the median line and forming a dense blotch at the posterior edge of the thorax. The abdomen bears a white or creamy band on the base of each segment; these widening out on the sides. The femora and tibiae of the legs are creamy, speckled with black; the tarsal segments have each a wide, creamy band at the base.

The larvae are found in grassy pools and bogs, associated with those of the other early spring breeding mosquitoes. The winter is passed in the egg stage, the larvae appearing very early in the spring. The adults are not often seen in Minnesota after the end of July. The larvae are fond of hiding under overhanging grass on the edges of the pools and for that reason may not be readily noticed. They bear the tuft of hairs on the antennae below the middle point. The scales on the eighth abdominal segment are twenty-four to thirty in number, arranged in three more or less regular rows; each scale bears a long, apical spine one-half to two-thirds the length of the entire scale, and also a row of stout spines on each side. The breathing tube is about five times as long as wide; the rows of spines are closely set except the terminal two which are far apart and some distance from the end of the row.

We have taken this species at Clear River, Roseau County, June 15, 1914; McGregor, Aitkin County, June 16, 1916, and at Frazee May 26, 1914. It is one of the abundant early spring forms of our northern counties.

Aedes auroides Felt.

A dark brown, medium sized mosquito, beak and legs brown and unbanded. The anterior margin and first longitudinal vein of the wings almost black. A broad, dark brown stripe passes down the center of the thorax, becoming lighter toward the posterior end; the rest of the thorax with golden scales. Abdominal segments have white basal stripes widening on the sides.

This is another one of the very early appearing forms in the northern part of the state, being found with *Aedes fuscus* and *Aedes abfitchii.*

We have taken adults at Clear River, Roseau County, June 15, 1915; at McGregor, Aitkin County, June 16, 1916, and at University Farm, June 23, 1916. They probably begin to appear in May. At

Fig. 21—Muskegs furnish ideal conditions for the production of early spring mosquitos.

these places they were very abundant. No observations have been made upon the life history, but it is safe to suggest that it resembles *Aedes fuscus.*

The larva is fairly large. The antennae bear the tuft of hairs at the basal third of their legnth. The sixteen scales on the eighth abdominal segment are arranged in a triangular patch; each scale is spatulate, with a stunt apical spine, the edges with stout setae. The breathing tube is stout, three times as long as wide, rows of spines twenty to twenty-four in number, each spine with one large and two to three smaller teeth.

Mansonia perturbans Walk—The Irritating Mosquito.

This mosquito is rather above medium size and of a general brownish color. Several prominent characteristics help to recognize it at once. The wings are heavily scaled with large oval scales of both a whitish and blackish color, giving them a mottled appearance. The beak is broadly banded with white at the middle and the tarsal segments bear broad white bands at their bases, as well as a white band at the middle of the first segment of the tarsi of the first pair of legs. The tibiae of all three pairs of legs also have a white band at the distal third of their length. The segments of the abdomen are very narrowly banded with white at their bases.

It is crepuscular in habits, but will attack during the daytime in shady woods. The popular name indicates the annoyance it causes to man. Apparently it has a wide distribution over the state. There is only one brood each year, adults appearing in June and continuing throughout the summer. The winter is passed in the larval stage, even if the water freezes solid. Eggs are laid on the surface of the water in rafts resembling those of *Culex pipiens*. It breeds mostly in swamps.

For a long time the larva of this mosquito was unknown, but recently it was found that it attached itself to the roots of aquatic plants, obtaining its oxygen by thrusting the breathing tube into the tissues of these roots.

The larva is short and thick-set, antennae very long; the tuft of hairs at the basal third of the length. The breathing tube is short and is sharply pointed for piercing plant tissues. On the eighth abdominal segment is a single row of long, slender, pointed scales, each with a fringe of small hairs on the sides.

We have taken the adult at the University Farm, June 23 and 29, 1916, and near Lake Calhoun, Minneapolis, July 15, 1916. In the collection of the Department are specimens labeled Gray Cloud Island, July 1, 1896, and Grand Rapids, August, 1896.

Culex tarsalis Coq.

This is a small, dark mosquito, somewhat similar in appearance to *Aedes canadensis*, like that species having the basal and terminal white band on the tarsal segments. They can be separated, however, by the fact that *Culex tarsalis* has a white band on the beak, a little before the middle of its length. The abdominal whitish bands expand laterally into broad white patches. The femora and tibiae are narrowly lined on each side with white and the tips are

white. The thorax is marked on the posterior half with two narrow white lines and a white spot on the posterior edge. They bite readily at night.

In the arid regions of North America this species is the dominant form. It occurs from the Pacific coast eastward across the Mississippi river, and southward into Mexico. It seems to be fairly common in Minnesota.

The larvae are said to occur in the edges of ponds and lakes where they are protected by a thick growth of vegetation but occasionally they may breed in artificial collections of water. The adults are supposed to hibernate.

The larva is rather slender; the tuft of hairs on the antennae is at the apical third of the length; the breathing tube is slender, a little over four times as long as broad; the spines on the tube, twelve to fifteen in number, are small with the base bearing seevral long teeth. The eighth abdominal segment bears a triangular patch of from thirty-two to thirty-five scales, each illiptical, bearing a long terminal spine and a fringe of small spines on the apex.

We have taken these mosquitoes as follows:

Larvae.

University Farm—In collections of water in cattle footprints near a watering trough; tin buckets and rain barrel, August 13, 1913; August 26, 1913; August 18, 1916. Adults were reared from these.

Adults.

Adults were collected several times in Minneapolis and at University Farm in August and September, 1916, but no more definite date record made. In the Department collection are two specimens bearing the date August 25, 1896, but no locality label.

Aedes trivittatus Coq.—The Three-Striped Mosquito.

These mosquitoes may be quickly recognized by the three dark stripes on the yellowish thorax. The legs and beak are unbanded. On each side of the abdominal segments is a white basal spot. These may frequently unite dorsally and form a narrow white band. It is a fierce biter but is never seen in a house, being found principally in woodland or near woodland.

The larvae breed in woodland pools, protected by shade or kept full by small springs. Headlee says that in New Jersey it is also found in company with larvae of *Aedes sylvestris* in open

pools. In appearance it is rather short and thick-set, the breathing tube is stout, about two and one-half times as long as broad, and almost black in color. The spines on the tube are curved and slender, and bear from two to three teeth at the base and are thirteen to eighteen in a row. The scales on the eighth abdominal segment are spatulate in shape and bear a long spine at the tip and a row of small spines on each side. They are placed in two irregular rows.

We have taken the adults of this species at University Farm, June 23, 1916, and at Fergus Falls, August 21, 1912. Apparently it is widely distributed through the State.

Anopheles punctipennis Say.—The Mottled-Winged Anopheles.

This Anopheles is fairly common in many parts of Minnesota. In the autumn of 1915 adults entered winter quarters in the basement of the Insectary building at the University Farm, but the severe winter seemed to kill them, for they could not be found toward spring. On August 20, 1913, larvae were found in the shallow margins of a large swamp at Savage, Minnesota. Again in July, 1915, larvae were found in large numbers in the lagoon in Langford Park, St. Paul, and in swamps near the University Farm. In the former place they were above large masses of algae in three or four feet of water. Except on this one occasion we have always found them in shallow water at the edges of swamps among water plants and often where there was considerable decaying plant material in the water. The species has an extensive range, being reported from New Jersey and New York south to Texas, west to Oregon, and north to Canada. The adults may become quite numerous, but rarely so as to become a serious annoyance.

The adult can be quickly distinguished from the other Minnesota anopheline by the somewhat smaller size; wings more densely clothed with darker scales, giving it a gray or blackish appearance; large yellowish spot near the apical fourth of the wing on the cephalic margin and a second yellow spot on the extreme apical margin.

The larva differs from the ordinary culicine larva by lacking the long breathing tube. It lies parallel to the surface of the water and close to the surface film instead of hanging downward at a sharp angle to the surface. The body is usually mottled with brown or grey in such a way as to make it hard to distinguish. Often the green algae taken in as food show through the body, adding to

the color pattern. Close examination reveals the fact that the head is turned toward the dorsal side when feeding, that is, they are surface feeders, whereas the Culicine mosquitoes feed mostly at the bottom of the water pool.

The adults hibernate. Eggs are laid singly on the surface of the water. Generation follows generation throughout the summer. Until 1915 it was thought that this species was not able to transmit malaria, but King, in 1915, showed that it was able to transmit tertian malaria.

We have taken this species, adults and larvae, at St. Paul and Savage, Minnesota, August 20, 1913, and July, 1915. In the department collection are specimens labeled St. Anthony Park, August, 1896.

Anopheles quadri-maculatus Say.—The Four-Spotted Anopheles.

This species does not seem to be as common in Minnesota as *Anopheles punctipennis*. It is larger than that species and of a yellowish or brownish color. On each wing the dark brown scales are grouped into four spots. It has a fairly wide range, but does not extend as far west as *punctipennis*, Manitoba being its westernmost record. It is more common in the southern part of its range.

The adults hibernate. Eggs are deposited in loose masses on the surface of the water. Breeding seems to be most active after August 1st. They may be found in any pool of water, even in rain barrels, although they prefer pools of water on the soil, open swamps choked with vegetation, grassy edges of swamps or places covered with water lilies or spatter-dock. Clean water is preferred to foul. Adults do not fly far from the breeding places, probably not more than half a mile at the most.

The department collection contains specimens labeled St. Anthony Park, June 11, 1895; October 23, 1895 to September, 1896; Grand Rapids, August, 1896.

Several other mosquitoes have been reported from Minnesota but have not yet been collected by us. They are apparently not very common.

Culex dyari: A brown mosquito, with golden scales on the thorax, except for two parallel stripes. The abdomen is nearly black, with yellowish bands; the tarsi are also ringed with yellowish white. There is apparently only an early spring brood, the species passing the winter in the egg stage. It does not seem to be a common species.

Aedes impiger: This is a brown mosquito with unbanded dark legs and beak, thorax covered with golden scales, abdomen with white bands expanding laterally.

Larvae are found with *Aedes canadensis*, *Aedes cantans*, and *Aedes fuscus* in the early spring. Felt states that it passes the winter in the larval stage.

Aedes triseriatus: Tree Hole Mosquito. A small to medium-sized mosquito, with black unbanded legs and beak. The sides of the thorax are silvery, shading to grayish on the back, but leaving a wide black band on the middle of the back; white lateral patches on the segments of the abdomen. It breeds normally in water collected in tree holes, but occasionally in pails or other wooden receptacles or even in water holes on the ground. It does not travel far for it is seldom found outside of the vicinity of woodlands. They apparently breed throughout the season, wintering in the egg stage. The larvae are long and snake-like, moving by sinuous, snake-like motions.

Aedes nemorosus: A northern species, more common in woodland than elsewhere. The adult is a large brown mosquito with a wide median dark brown band on thorax; abdomen white banded; legs unbanded. Larvae are found in collections of water, ditches, etc., in woodlands and fields. It occurs in Europe and northern North America.

Aedes curriei: A rather rare mosquito of a pale yellowish white color; thorax with central stripe of golden scales; abdomen diffused with white scales, leaving only two small dark blotches on each segment; wings hyaline. The species has been reported from North Dakota, Colorado, Idaho, California, and British Columbia. In the departmental collection is a specimen labeled Crookston, Minnesota, August 15, 1896.

Wyeomyia smithii: The "pitcher plant mosquito." A small, black mosquito with abdomen, legs and beak unbanded; the whole under surface of the thorax and part of the under sides of the legs is yellowish or silvery white. It never bites man. The larvae breed in the water collected in the leaves of pitcher plants, in which they hibernate as larvae, freezing up in the ice.

STUDIES IN GREENHOUSE FUMIGATION WITH HYDROCANIC ACID

Temperature and Moisture as Factors Influencing the Injury of Plants During Fumigation.*

William Moore.**

INTRODUCTION.

A cursory review of the literature dealing with the fumigation of greenhouses with hydrocyanic acid reveals a great diversity of opinion among entomologists as to the most successful doses to be used, and the influence of various physical factors in the success of the fumigation. Although hydrocyanic acid fumigation has been used in greenhouses since 1899 (1) our knowledge of the conditions necessary for successful fumigation although largely empirical, has brought about its general use for certain insects and crops, such as red spider on violets and white fly on tomatoes and cucumbers.

The most important question to be answered, before taking up an examination of the influence of any factor in increasing or decreasing the injury to plants during fumigation, is the manner in which the gas penetrates the tissues of the plant.

The Penetration of the Gas Into Plants.

Woods and Dorsett (1) considered that hydrocyanic acid gains entrance to the plant by way of the stomata while Stone (2) considers from his work that susceptibility to injury is due more directly to the condition of the tissue of the plant rather than the open or closed condition of the stomata. Conditions which tend to develop a thin cuticle were found to favor injury during fumigation.

The following experiment was conducted to determine if hydrocyanic acid would cause the stomata of the plant to close during fumigation. Peas, lettuce and geraniums were fumigated with hydrocyanic acid under a bell jar in the bright sunlight. Similar plants were placed under a bell jar in the sunlight as a control. Strips of the epidermis of the plants were obtained after different exposures, and dehydrated with absolute alcohol, stained, mounted

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and studied (3). The average of twenty measurements of a pea is given as an example.

Control at start	Fumigated 5 min.	Fumigated 30 min.	Fumigated 60 min.	Control 60 min.
2.15 m	2.21 m	2.32 m	2.72 m	2.61 m

Pfeffer states that "Filtration and gaseous diffusion takes place through the stomata, lenticels, etc., and their rapidity varies inversely as the square root of the density of the gas concerned" (4). Inasmuch as hydrocyanic acid does not cause the stomata to close,* it would therefore gain entrance inversely as the square root of its density. The rate of diffusion of carbon dioxide known to enter the stomata, compared with air is .8087 while hydrocyanic acid is 1.0276. Hydrocyanic acid could therefore more easily enter the plant by means of the open stomata than carbon dioxide.

This conclusion agrees with the results obtained in fumigation. Plants fumigated during bright sunlight when the stomata are open will show more injury than similar plants fumigated at night when the stomata are closed. Further, the nature of this injury is a spotting of the mature leaves, the stomata of which are abundant and active while injury produced by night fumigation is in general confined to the youngest leaves having the thinnest cuticles.

According to Pfeffer the passage of a gas through the cuticle of a plant depends upon its solubility in water and the extent to which the cuticle is impregnated with cutin, or suberin. The following experiments were devised to show if hydrocyanic acid could pass through the cuticle of greenhouse plants.

Lettuce plants exposed to the vapor of osmic acid in the sunlight when the stomata are open will show a spotting or mottling of the mature leaves. Examination of the cuticle reveals that the spotting is due to the penetration of the gas through the stomata. A similar burning of the leaves is produced by hydrocyanic acid fumigation under similar conditions but the injured areas are not as sharply defined, due to the great solubility of the hydrocyanic acid and its diffusion through the tissues of the leaves. If a lettuce plant with closed stomata is exposed in the dark to

Fig. 22

*If the plant takes in sufficient hydrocyanic acid to be injured the stomata close after the fumigation or during the fumigation if it exceeds an hour exposure or if the dose is very strong resulting in the immediate injury of the plant.

the vapor of osmic acid the youngest leaves turn uniformly black, and if the time of exposure is extended the other leaves take on a similar appearance from the youngest to the oldest. One does not obtain a spotting as in exposure in sunlight. An examination of the cuticle shows a uniform blackening due to the penetration of the osmic acid vapor through the cuticle and not by way of the stomata. Exposure to hydrocyanic acid under similar conditions results in a burning and death of the youngest to the oldest leaves according to the length of exposure. Since the penetration of a thin cuticle, such as lettuce, depends upon the solubility of the gas or vapor concerned, naturally hydrocyanic acid, which is soluble to infinity in water, could pass where osmic acid, which is but slightly soluble, gained entrance.

To test the passage of hydrocyanic acid through cuticles of different thicknesses and degrees of cutinization ,an apparatus shown in figure 1 was devised. The upper end was closed with a piece of cork through which a hole about one-third of an inch in diameter was made. A very fine mesh wire was placed over this opening and fastened to the cork with sealing wax. Leaves without stomata on the upper surface were selected and a piece cut from the desired leaf was placed with the upper surface next to the wire. The leaf was then carefully sealed down with wax, making the chamber air tight. The lower portion of the tube was filled with hydrocyanic acid gas by collection over mercury, and while the lower end remained in the dish of mercury, the dividing stop-cock was opened. The upper surface of the leaf was thus exposed to the hydrocyanic acid gas and as it was absorbed by the cuticle the mercury rose in the tube. The accompanying table gives data obtained by the use of this apparatus.

Plant	Temperature at Start	Temperature at Close	Time	Total Rise	Average per hour	Thickness of Cuticle
Tradescantia	65° F.	69.5° F.	4 hrs. 30 min.	25 mm	5.5 mm	.964 m
Vinca	73.5° F.	75.5° F.	17 hrs.	65 mm	3.8 mm	1.02 m
Azalia	69° F.	69° F.	18 hrs.	81 mm	4.5 mm	2.09 m
Citrus	68° F.	68° F.	19 hrs. 35 min.	60 mm	3.0 mm	2.15 m
Ivy	64° F.	64° F.	6 hrs.	0 mm	0 mm	3.29 m
Aspidistra	75.5° F.	74.5° F.	23 hrs. 45 min.	25 mm	1. mm	3.35 m

Figure 23 gives the appearance of cross sections of these leaves. An increase in thickness is generally accompanied by an increase of cutin or suberin which will stain with sapranin. Al-

though the azalia in thickness almost equaled the citrus, the staining with safranin gave a very faint pink in azalia compared with the deep pink or red of the citrus.

The concentration of hydrocyanic acid gas to which these leaves were exposed was much higher than would be encountered in fumigation, but the results are comparable. Hydrocyanic acid gas can enter plants through their cuticle but to a lesser extent or not at all in the case of thick, strongly cutinized cuticle. General observations show that the fumigation, in the dark, of plants with closed stomata, will injure those with thin cuticles, such as lettuce, tomatoes and cucumbers, far more severely than those with thick, strongly cutinized cuticles, such as citrus, aspidistra, etc. The following experiment will serve as an example. The dose was 10 ozs. of potassium cyanide per 1.000 cu. ft. for one and a half hours. Of the plants present the lettuce, tomato and cucumber were completely destroyed, half of the leaves of the transdescantia were burned, the youngest leaves of the geranium and crimson rambler, and the growing tips of the ivy and vinca were injured while the azalia, aspidistra, citrus and nasturtium were uninjured.

From the evidence cited, the conclusion may be drawn that hydrocyanic acid enters the plants during fumigation through the stomata if they are open and also through the cuticle, depending upon its thickness and degree of cutinization. The question can now be considered as to the rôle of moisture and temperature on the penetration of the gas.

MOISTURE.

Influence of Moisture Present In the Greenhouse.

Inasmuch as hydrocyanic acid is soluble to infinity in water any moisture present in the greenhouse at the time of fumigation must be important. All the water present in the greenhouse on the walks, on the glass, in the soil, on the plants, or in the air dissolves the hydrocyanic acid liberated by the charge. Penny (5) has shown that in a closed room about 50% of the hydrocyanic acid is lost within one hour after the beginning of the fumigation, while wet leaves will account for 25% in five minutes and wet soil 38% in a similar period.

Moisture present in the greenhouse during fumigation therefore tends to reduce the quantity of hydrocyanic acid present in the air.

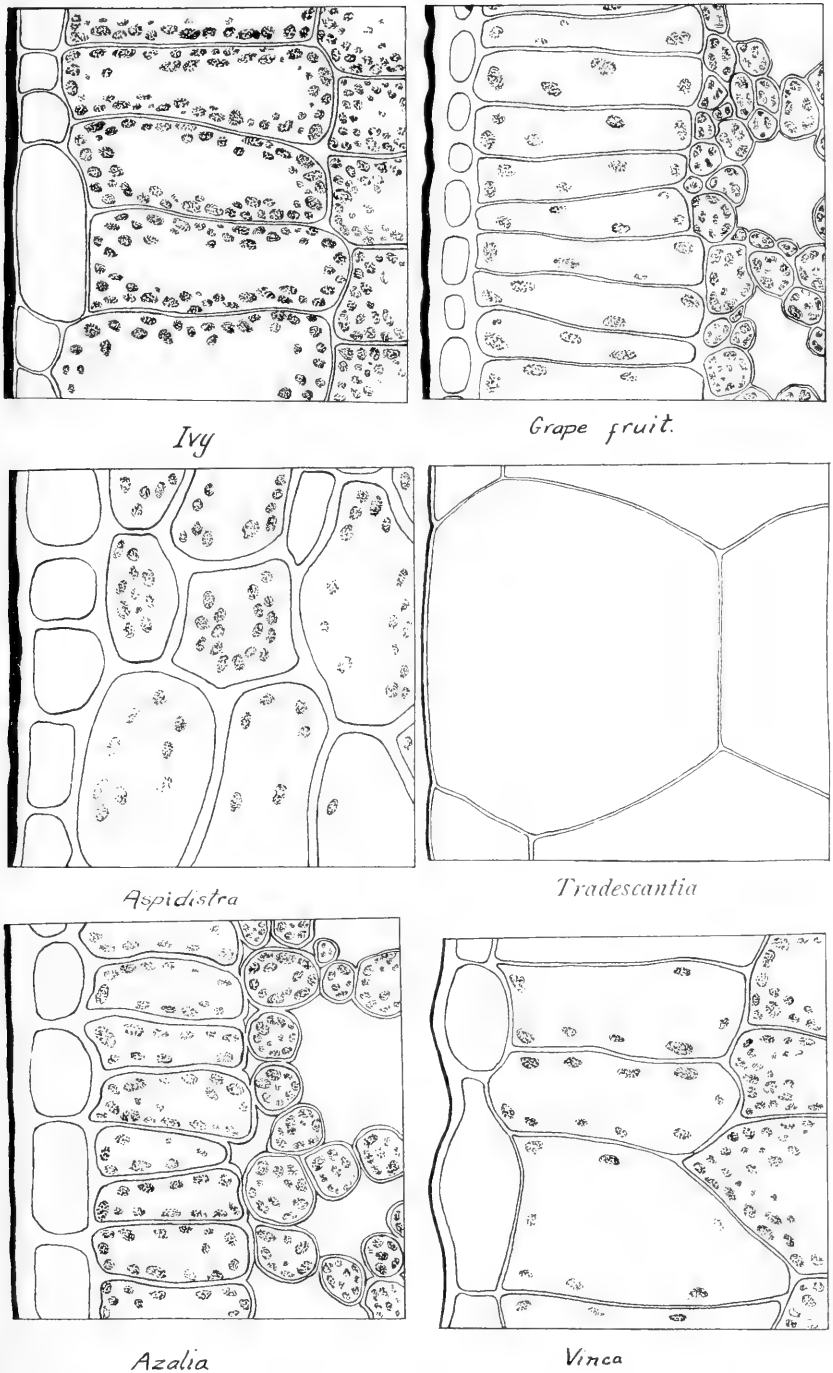

Fig. 23. Comparative thickness of the cuticle of Aspidistra, Tradescantia, Grape Fruit, Vinca, and Azalea.

Moisture Upon the Leaves of the Plants.

Moisture upon the leaves absorbs hydrocyanic acid, thus forming drops of prussic acid on the leaves. These increase in strength during fumigation, giving the hydrocyanic acid an excellent opportunity to pass from the drop through the cuticle to the plant tissues. The ability to enter the cuticle depending upon its cutinization, workers using different plants have arrived at different conclusions as to the injury resulting from wet leaves at the time of fumigation. Johnston states, "Lettuce, cucumbers, and canteloupes are very easily injured if the plants are damp, even with small amounts of gas" (6). Woglum (7), working with citrus plants, reports, "From all this experience, not a single authentic instance has been seen in which burning was directly attributable to absorption of gas by the moisture on the fruit or leaves." In a series of experiments carried out where the leaves of the plant were wet, the results showed an injury to the foliage of lettuce, tomatoes, begonia, tradescantia, cineraria, geranium, and similar plants with thin cuticles while citrus, aspidistra palms, and ivy, were not injured.

In the fumigation of plants with thin, slightly cutinized cuticles, the leaves should be perfectly dry, but in dealing with plants with thick, strongly cutinized cuticles the leaves may be wet or dry without causing injury. Moisture on the leaves may be present, due to several causes, watering the plants just preceding fumigation, dripping from snow or rain on the roof, and exudation of water from the water pores of the plant. A peculiar case of injury due to moisture on the leaves is shown in Figure 24-1 of eucalyptus leaves, burned by hydrocyanic acid dissolved in nectar which had dropped down upon them from the flowers of a cobea growing overhead.

Soil Moisture.

In daylight fumigation soil moisture favors injury to the plants. A typical experiment was one in which six sets of tomato plants were used. Set I dry, not watered for 24 hours, nearly wilting; Set II wet, abundant water in the pots; Set III dry, as in Set I, but the soil coated with paraffine; Set IV wet and coated with paraffine; Set V dry, but watered immediately after fumigation to bring any hydrocyanic acid in the loose soil in contact with the organic matter and thus aid its decomposition; Set VI, both wet and dry soil coated with paraffine but not fumigated. The result showed the plants in wet soil were more severely injured than those in dry soil regardless

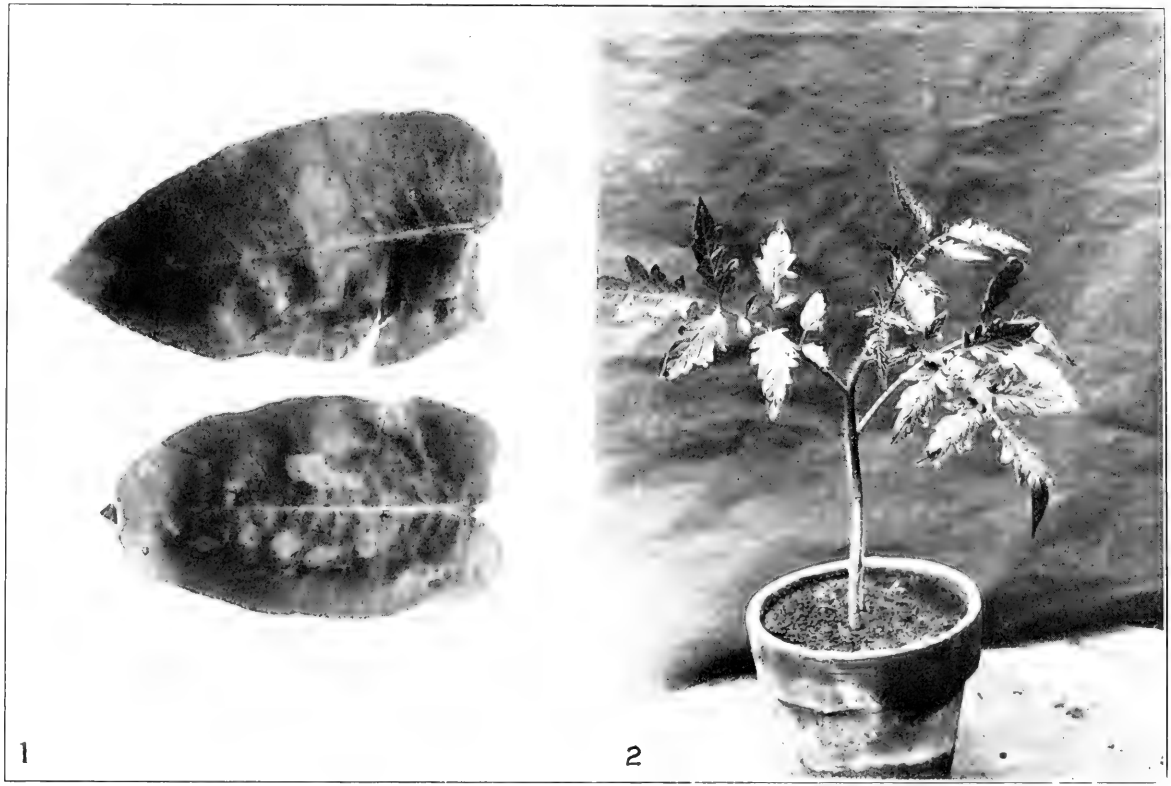

Fig. 24—1. Leaves of eucalyptus burned by hydrocyanic acid dissolved in the nectar present on them at the time of fumigation.
2. Tomato plant showing exudation of water from the water pores along the edge of the leaves.

of whether they were paraffined or not, and the period of time at which they were watered after fumigation. Figure 25. This experiment shows that the injury was not due to the absorption of the hydrocyanic acid by the soil. Chemical analysis revealed the fact that hydrocyanic acid is decomposed by the organic matter of the soil. Examination proved the stomata of the plants in dry soil to be closed and those of plants in wet soil open. Soil moisture is of more influence in day fumigation than in night fumigation when other factors cause the closing of the stomata. Inasmuch as abundant soil moisture favors the exudation of water from the water pores of certain plants excessive moisture should be avoided. Stone has shown that plants grown under moist conditions tend to produce thinner cuticles, thus making them more liable to injury (*2*).

Relative Humidity at the Time of Fumigation.

After a series of preliminary experiments which showed that relative humidity has an influence, the following experiment was conducted as an example of the influence of relative humidity upon injury to tomato plants. The dose in each case was 1½ oz. of potassium cyanide to one thousand cubic feet of air in a small greenhouse. The time of exposure was one hour, at the close of which the house was aired and the plants removed to another house to prevent any later influence acting upon them. Heavy curtains were drawn to shut out any possible light, although it was night.

	Av. Temp.	Av. Rel. Humidity	Result.
Set I	48.5° F.	85.5%	Plants severely injured.
Set II	45°	69.5%	Plants not injured.
Set III	89°	54%	Plants not injured.
Set IV	88.5° F.	62.5%	Plants showed a slight curling of the leaves.
Set V	83.5° F.	76%	Leaves of plants curled.

The injury under the different conditions is shown in Figure 26. From this experiment it is apparent that the actual amount of moisture in the air has little influence but that injury is caused by the influence of the relative humidity on the rate of evaporation. In other experiments different plants were used and in general similar results were obtained. Plants with thick, strongly cutinized cuticle are less influenced by relative humidity than plants with thin cuticles, such as tomatoes.

The effect of relative humidity is probably accomplished in two ways, (1) by a tendency of the plant to slightly open its stomata under high humidity to increase transpiration, and (*2*) by preventing the evaporation of moisture from the cuticle.

Fig. 25—Injury to plants growing in wet soil compared to injury to plants in dry soil.
1. Two days after fumigation.
2. One week after fumigation.

When the relative humidity is low and evaporation is rapid, the hydrocyanic acid would be evaporated as fast as it dissolved in the moisture of the cuticle, and no opportunity would be given it to diffuse from the cuticle into the tissues of the leaf. Plants with thin cuticle are influenced more by the relative humidity than those with a thick, waxy cuticle.

Relative Humidity After Fumigation.

The influence of relative humidity is not confined to the time of fumigation. A number of tomato plants fumigated side by side were divided into two lots at the close of the fumigation, one of which was placed under humid conditions, 99%, 86° F., the other dry conditions, 15%, 86° F. for a period of 12 hours. The plants under a high relative humidity were more severely injured, as shown by Figure 27. The hydrocyanic acid is apparently dissolved in the cuticle of the leaf, but is rapidly evaporated under the low relative humidity before it has an opportunity to reach the cells below, while it is retained under the high relative humidity and passes from the cuticle to the cells below, producing its typical injury. Plants with thick, waxy cuticles are not so easily affected by a high relative humidity. Citrus plants even fumigated with drops of water on their leaves were placed under wet and dry conditions after fumigation without injury resulting.

TEMPERATURE.

Influence on the Gas in the House.

An obvious influence of high temperature is to increase the diffusibility of the hydrocyanic acid present in the air during fumigation. Inasmuch as the uneven distribution of the gas in the greenhouse at the beginning of the fumigation is a source of danger to the plants, a higher temperature which hastens diffusion is beneficial. On the other hand, a warm house, when the outside temperature is low, facilitates the escape of the vapor through the crevices of the glass, thus rapidly reducing the concentration of hydrocyanic acid. When the outside temperature is so low that ice fills the crevices of the glass the leakage of vapor from the house is checked. Such a house is extremely tight and in fumigation under such conditions it is advisable to reduce the dose.

Influence of Temperature on the Penetration of the Gas.

One would expect that an increase in temperature causing an increase in the rate of diffusion through the stomata of the plants would tend to increase injury to the plants. An increase in the

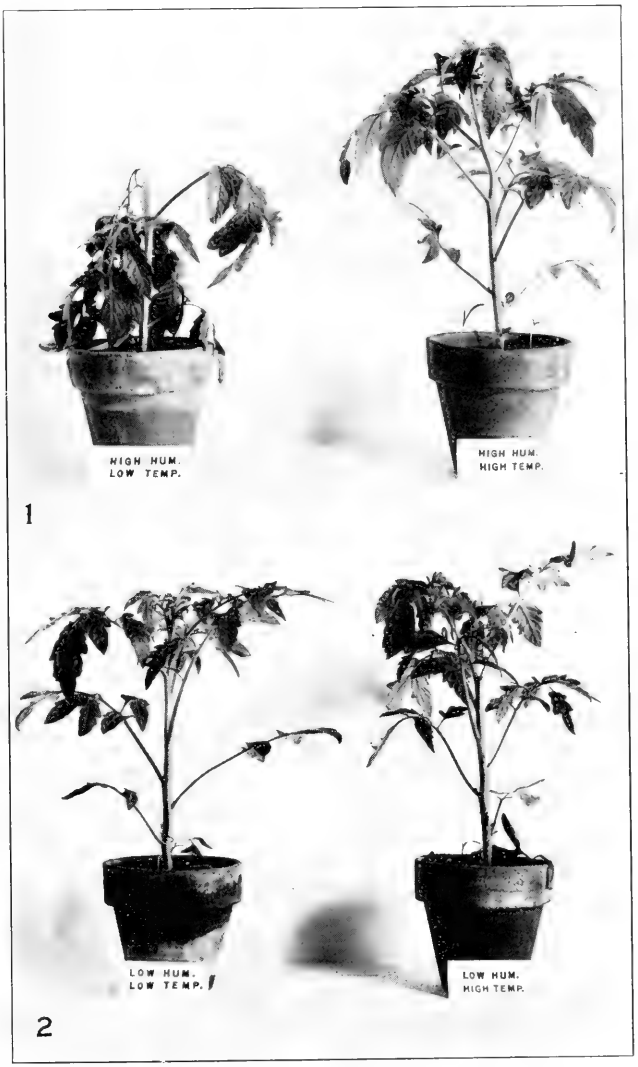

Fig. 26—Effect of temperature and humidity.
1. 45° F.—69.5% humidity.
89° F.—54% humidity.
2. 48° F.—85.5% humidity.
88.5° F.—62.5% humidity.

temperature, however, is accompanied by a decrease in the relative humidity, thus producing a tendency in the plant to close its stomata. Further during night fumigation, as has been shown, the hydrocyanic acid enters primarily through the cuticle, and the rate of diffusion will not be of as great importance as the nature of the cuticle. Although most investigators consider that a high temperature favors injury, Tower states, "The results in variation of temperature of the house during fumigation were by no means as noticeable as had been anticipated; indeed, as a result of these tests, it would seem to make little difference whether treatment should be given in a warm or a cool house." (8).

Throughout our experiments we found that a high temperature was beneficial rather than injurious. Two experiments may be noted. Geraniums, sweet peas, crimson rambler rose, and cucumbers were exposed for four hours to a dose of 7 ounces per 1,000 cubic feet, at a temperature of 96° F. and a relative humidity of 39%. The result was a burning of the tips of the sweet peas, the buds of the rose, a few of the youngest leaves of the geraniums and the shoots of the cucumbers. In the experiment previously cited under relative humidity the tomatoes of Set I fumigated under an average temperature of 48.5° F. were severely injured. Sets III, IV and V, 83.5° F. to 89° F., were either not injured or but slightly injured. Figure 26. A high temperature reduces the relative humidity and increases evaporation, hence would act as a low relative humidity and would be beneficial.

If the temperature is high during a short fumigation in airing out the cold air tends to deposit moisture upon the leaves of the plants. This moisture contains hydrocyanic acid and in the case of plants with thin cuticles will cause injury. One such case noted in the work may be of interest. A greenhouse filled with lettuce was fumigated at the rate of ½ oz. of potassium cyanide to each 1,000 cu. ft., for a period of 1½ hrs. The temperature of the house preceding fumigation was 50° F., but was raised to 58° F. before the charge was put in. The relative humidity was 89%. In airing out the house the temperature was lowered to 50° and remained at that temperature for the rest of the night. The plants were injured apparently from the moisture deposited upon them when the house was aired. To prove this point lettuces were raised under similar conditions the following year and fumigated over night with ½ oz. of potassium cyanide per 1,000 cu. ft. without injury to the plants. Later they were again fumigated in an attempt to reproduce the conditions of the preceding experiment. The

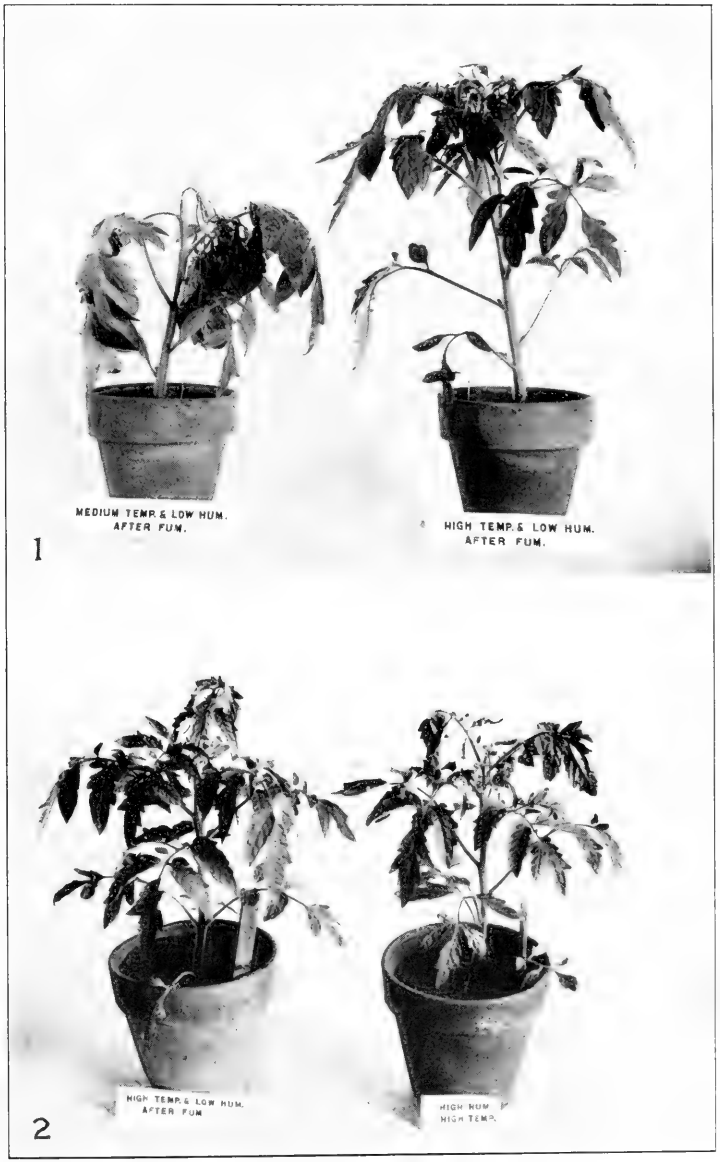

Fig. 27—Effect of temperature and humidity after fumigation.
1. 65° F.—35% Humidity after fumigation.
86° F.—15% Humidity after fumigation.
2. 86° F.—15% Humidity after fumigation.
86° F.—99% Humidity after fumigation.

plants were dry at the beginning of the fumigation. The temperature was 62° F. and the relative humidity 89% (as the temperature outside was much higher than when the previous fumigation was conducted a temperature of 59° F. could not be obtained and still permit a drop in temperature in airing out the house). The charge remained in the house for one hour and two minutes when it was aired out, and the temperature lowered to 57° F. The plants were examined and moisture was found on the leaves. The plants were injured in a similar manner to those of the previous experiment at least 60% being unfit for market.

Low temperatures during fumigation are liable to produce injury in still another way. If a house is warm during the day and cooled off at night in preparation for fumigation the soil temperature will be higher than the air temperature. If the soil is moist the plants will take up water from the soil faster than they can evaporate it from their leaves. In many plants such as lettuce, cucumbers, tomatoes and others this will produce an exudation of water from the water pores of the leaf. Figure 24-2. This water takes in hydrocyanic acid during the fumigation resulting in the burning of the edges of the leaves. This type of injury is frequently encountered unless great care is taken to avoid it. The temperature the day preceding fumigation should be low, increasing to 70° F. at the time of fumigation. No exudation will then occur unless the relative humidity becomes high, which is not liable to occur unless the temperature drops.

Influence of Temperature After Fumigation.

What has been stated to be the influence of the relative humidity after fumigation is equally true of the temperature. A low temperature acts as a high relative humidity, while a high temperature acts as a low relative humidity. The temperature no doubt does not produce its results directly, but by its influence in controlling the relative humidity and the evaporation from the plant. Figure 8.

A high temperature will cause the injury from the fumigation to show quicker than a low temperature, but the final injury will be very much less in the case of a high temperature than in that of a low temperature. The reason for this will be discussed in a later paper dealing with the action of the hydrocyanic acid after it has entered the plant cells.

CONCLUSION.

From the results reported the following procedure should be followed in the fumigation of a greenhouse. Plants should not be watered for 24 hours preceding fumigation to insure that the house is dry and the relative humidity low. The day temperature preceding fumigation should be low, gradually rising to 68°-70° F. at the time the charge is put in. This insures the temperature of the soil being lower than the air of the house, and the relative humidity being low prevents exudation of water from the water pores of the leaves. After the fumigation is started, the temperature is permitted slowly to rise to 75° F. The rising temperature causes a decrease in the relative humidity and favors evaporation from the leaf surfaces. If a strong dose is given for a short time the temperature during fumigation should be lower and care taken in airing out the house that moisture containing hydrocyanic acid is not deposited upon the plants. After ventilating the house the temperature should rise to 70° to 75° to remove any hydrocyanic acid on or in the cuticles of the leaves. Plants with thin cuticles such as lettuce, cucumbers, tomatoes, etc., are more liable to injury from strong doses for short periods than from small doses for longer periods. Plants with thick, waxy cuticles can withstand very strong doses for short periods, granting that the fumigations are carried out during the night when the stomata are closed.

Doses of from ¼ oz. to ½ oz. of potassium cyanide per 1,000 cu. ft. may be used overnight if the plants have thin cuticles. As most of the hydrocyanic acid has disappeared by morning the house may be ventilated without danger to the plants.

Following these principles a number of greenhouses have been successfully fumigated. In one case a greenhouse contained roses and chrysanthemums in full bloom, smilax, ferns, and other greenhouse plants. One-fourth ounce was used and the following morning the white fly and even the aphids in the heart of the chrysanthemum flowers were dead without the slightest injury to any of the plants.

SUMMARY.

Hydrocyanic acid may enter a plant either through the stomata or directly through the cuticle.

The amount of hydrocyanic acid which will enter the cuticle of the plant depends upon the thickness and the degree to which it has been cutinized.

Moisture on the leaves aids the gas to penetrate, but is not so important a factor where the house contains only plants with thick, heavy cuticles.

Moisture may be present on the leaves, from sprinkling the plants or from exudation of water from the water pores.

High relative humidity at the time of fumigation aids the penetration of the gas through the cuticle, thus favoring injury.

High relative humidity after fumigation tending to prevent evaporation of hydrocyanic acid in the cuticle of the plant tends to increase injury to the plants.

Low temperatures at the time of fumigation and after acts in a similar manner to a high relative humidity.

High temperature by increasing evaporation produces results similar to a low relative humidity.

Both high relative humidity and low temperature have less influence on plants with thick, waxy leaves.

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THE STRAWBERRY WEEVIL IN MINNESOTA

Anthonomus signatus Say

Suborder—*Rhynchophora*
Family—*Curculionidae*
Tribe—*Anthonomini*

S. MARCOVITCH.

The work of which the results are here offered in detail was begun at the University of Minnesota in 1914, at the suggestion of Professor William Moore, then in charge of the Section of Truck Crop Insects. The investigation was completed under Professor Ruggles, in charge of the Section of Economic Entomology. I wish to thank both Professor Moore and Professor Ruggles for valuable suggestions throughout the work and for criticism of the manuscript.

The strawberry weevil was found to be very destructive during the last few years, in Minnesota, especially in the vicinity of Minneapolis and Hopkins, where it is not uncommon to find fields with from forty to ninety-five per cent of the buds severed. One of the first indications of its presence is a shortage in the number of blossoms, usually attributed to frost, hail, or some other agency.

HISTORY AND DISTRIBUTION.

The strawberry weevil is a widely distributed native species, being first reported as injurious to strawberries in 1871, by Mr. Townsend Glover, at Silver Hill, Maryland. Since then it has been reported from Missouri, 1873; Michigan, 1883; Staten Island, 1885; New York, 1886; Ontario, 1886; Quebec, 1887; Pennsylvania, 1888; Virginia, 1891; New Hampshire, 1891; Delaware, 1892; New Jersey, 1893, and North Carolina and Ohio, 1893. In Minnesota, this insect is first mentioned in Luggar's Fifth Report, 1899, as occurring in limited numbers, and later is reported by Washburn in 1903 and 1904. During the last two years, the weevil has appeared in such numbers as to warrant further study. Although the weevil is very abundant at Hopkins, Minnesota, it has not been reported as injurious in other parts of the state, owing possibly to the lack of information on the part of the growers. The weevil was found by the writer at Faribault, Itasca Park, Brainerd, and as far north as Duluth, and is probably distributed over the entire state, wherever strawberries are grown.

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LOSSES.

In Virginia and some of the other southern states, many truck growers have abandoned the growing of strawberries because of the work of the weevil. In Minnesota, one farmer reports a yield of twenty-two crates in 1916, while from a similar patch he obtained one hundred twenty-five crates in 1912. Although some of this loss was due to winter-killing of the plants, the weevil is responsible for the greater share.

FOOD PLANTS.

Plants Found On.

The weevil was found cutting the buds of the wild strawberry, dewberry and red raspberry, especially the raspberry (Fig. 2, Pl. II), while blackberries near by were not injured. Weevils were also found in the flowers of the Horsemint *(Monarda fistulosa)* growing in the strawberry patch, on July 26, 1916. Of the cultivated strawberries, the most widely grown in Minnesota is the Dunlap, which suffers severely from the ravages of the weevil, since it is a staminate variety. As is well known, the weevil is restricted to the staminate varieties, particularly those which furnish considerable pollen, since this constitutes the chief food of both larvae and adults.

Effect on Everbearing Strawberries.

On July 9, the weevil was reported cutting the buds of everbearing strawberries. Upon examination, beetles, as well as eggs and larvae, were found in the cut buds. This presented an interesting case, for at the time it was difficult to tell whether the hibernating weevils or those just emerging were responsible for the damage. Cages were set up in the field and in the insectary over plants, some with hibernating weevils and others with recently emerged ones. Four mature eggs were found in a weevil discovered in the field on July 9. On July 24, the weevils had almost entirely disappeared from the plants, and no fresh buds were found cut, although an egg was found in a bud lying on the ground. The fact that this particular everbearing patch was close to an infested June-bearing patch accounts for the presence of the weevils on July 9. That the weevils of the new brood under the cages are unable to oviposit the same summer was proved experimentally, for no eggs were found upon dissection. They appeared to feed voraciously, puncturing and withering the buds, which, however,

contained no eggs. It appears that the old weevils had simply migrated over to the everbearing patch and continued cutting off the buds for a week or two after the berries of the June-bearing varieties had been gathered. If the buds are kept off for a week or two after the June varieties have been picked, no serious injury will result and some of the weevils will be prevented from reaching maturity.

DESCRIPTION.

Adult.

After Dietz—"*A. signatus* Say—Robust, oval, piceous; elytra red, denuded fascia and scutellar space darker, thinly clothed with whitish pubescence. Beak moderately slender, feebly curved, subopaque and rather densely striatopunctate; median carina smooth, distinct. Antennae testaceous, club darker, funicle rather stout, outer joints distinctly wider, second joint distinctly longer than the third, but not slender; joints 3-7 transversely rounded. Eyes moderately convex, free behind. Head convex, occiput somewhat shining, front with a few remote punctures, finely and indistinctly rugulose, frontal puncture distinct. Prothorax wider than long, moderately narrowed in front; sides not strongly rounded, feebly constricted at the apex and transversely impressed behind the anterior margin; surface rather coarsely and densely punctured, pubescence condensed along the median line. Elytra less than one-fourth wider at the base than the prothorax and about one-half longer than wide, a little widened to behind the middle; sides feebly rounded; striae impressed, punctures moderately large, close set and becoming smaller towards the lateral margin; interspaces slightly convex, shining with an irregular row of fine punctures; the denuded fascia extends from the side to the third interspace, another denuded spot on the second interspace; scutellar space and along the suture darker; scutellum and intrahumeral spot densely pubescent. Thorax underneath more densely clothed with white, squamiform pubescence. Abdomen sparsely pubescent, segments transversely strigose, first and second segments rather long. Legs slender, femora feebly clavate, piceous, all armed with a sharp, well-marked tooth; tibiae paler, anterior feebly bisinuate, middle and posterior nearly straight, tarsi pale, first joint elongate. Long. 2-2.9 mm; .08—.12 inch."

Pupa.

(Fig. 6, Pl. I.) Length 2.3 mm., width 1.5 mm.; color creamy white. The eyes are the first to turn to a dark reddish color, while

the mandibles and tarsal claws show through the pupal skin. A little later the proboscis and elytra become darker than the rest of the body, and a day or two before emerging, the pupa becomes dark colored. The beak rests on the venter of the body with the legs drawn up at the sides. The elytra curve towards the venter. A round spiracle is visible just posterior to each eye. The hairs appear to rise from small tubercles, there being a pair of very small ones just anterior to the eyes, with a larger pair between the eyes. Another pair of hairs is found on the beak just above the insertion of the antennae, with a minute pair a little farther down the beak. From a dorsal aspect three pairs are visible on the anterior margin of the prothorax; a large pair on the mesoscutum and four pairs on the metascutum. Several spines occur on the abdomen, among which the lateral ones are more prominent than the others. The last abdominal segment is prolonged into a pointed process bearing two prominent brownish spines (Fig. 5, Pl. 5).

Larva.

(Fig. 5, Pl. 1.) Length, 1.7-2.2 mm., width, 1 mm., width of head 0.4 to 0.6 mm. Color greenish white or whitish, sometimes mixed with patches of reddish brown and with a reddish stripe on the dorsum. Nearly cylindrical but slightly flattened on venter, with the abdomen curved ventrally. Anal segment somewhat lighter in color than the others, dorsum strongly wrinkled, with the venter smooth. When nearly ready to pupate, the larva becomes cream colored, swellings appear on venter of thorax, and the body becomes straighter. Head about as long as broad, light yellowish; front yellowish; epistoma and mandibles darker; epicranial suture extending nearly to epistoma. Antennae minute, one-jointed, situated at base of mandible. The dark brown mandible is bidentate. A small black eye spot laterad to the antennae. Body of larva covered with many fine hairs.

The Egg.

The egg measures about .55 mm. long by .40 mm. wide and is elliptical in form, although the shape and size vary considerably. It is smooth with no visible markings (Fig. 3, Pl. 1).

LIFE HISTORY AND HABITS.

The Adult.

Feeding habits in the spring.—On May 5, 1916, the weevils were found in large numbers in an old patch, and the young tender leaves were conspicuously dotted with small punctures on the un-

der surface (Fig. 1, Pl. III). The leaves are close to the ground at this time, and spraying the under surface would be impracticable. In a new patch 120 feet away, neither beetles nor feeding punctures could be found, but their presence became marked as the season advanced. When the buds become more mature the adult weevils obtain the greatest share of their food, and their most important food, from the pollen within the buds. They also feed on the petals after the buds open, making small round holes in them, and to some extent, at the bases of the sepals and in the tissue from which the anther filaments arise. In some cases, the filaments are so girdled by their punctures that later they turn brown.

Copulation.—Copulation was observed to take place for about five minutes, although the male will often ride around on the back of the female for a much longer period. During the act of copulation their bodies are at right angles to each other and the tips of their abdomens are together.

Oviposition—Examination and selection of uninfested buds.—Oviposition was observed several times and found to take place in the following manner: The female crawls about a nearly matured bud examining it carefully with her antennae. After a period of from one to two minutes, a spot is selected in the crevice of an upright sepal near the middle of the bud. If the bud is already cut, with an egg inside of it, she refrains from ovipositing in it, and passes on to examine other buds that have not been cut, although two and even three eggs have been found in a single bud when the beetles are abundant and many of the buds cut. If two or more hatch in a bud, one is very likely to destroy the other, so that usually only one larva develops.

The act of oviposition.—The favorite position of the weevil in drilling a hole through the calyx, is with its head towards the base of the bud. Having obtained a firm position, she proceeds to drill the hole with her tiny mandibles. With an up and down motion, the head is thrust into the bud, and a place is cleared for the egg by feeding on the anthers or otherwise. After this operation is finished she withdraws her beak, turns about, and places the tip of her abdomen directly over the puncture, into which the ovipositor is protruded. The egg having been inserted, the ovipositor is withdrawn, and the egg sometimes poked in with her snout. If the beetle is disturbed during the process of drilling the hole, she removes her snout, rests on one side of the bud, and completes the hole when the disturbance is over. Sometimes the female will fail to locate the hole with her ovipositor when thus disturbed. She

then runs nervously back and forth over the bud hunting the hole with her antennae, and if successful thrusts her beak into the puncture for a few minutes to make sure of the right place. The beak is then removed and oviposition is again attempted. This process may be repeated several times.

The severing of the bud.—Crawling down to the base of the bud, she begins to sever it from the stem, about $\frac{1}{16}$ of an inch from the base of the bud, although stems have been found cut at various distances, up to one inch, from the bud. The usual position assumed is with the hind legs resting against the base of the bud (Fig. 1, Pl. II), while the middle and front legs rest on the stem. As the beak sinks into the pedicel, the forelegs are spread until they nearly clasp the stem, which is cut straight across or more often obliquely (Fig. 2, Pl. 2). Enough of the stem is cut so that the circulation is cut off and the flow of sap arrested, the cut end turning black after a short time. Within a few days the bud droops, discolors, and finally falls to the ground.

Time required for oviposition.—The time for making the egg-laying punctures varied from seven to twelve minutes, with an average of about ten minutes. The time required to lay the egg varied from thirty seconds to two minutes, while the cutting of the stem varied from ten to forty-five minutes, according to its thickness. In one case the weevil started the cutting so obliquely that the cut ran into the bud proper and could not be completed. At the time, a male was sitting on her back and perhaps distracted her. A fair average, then, for complete oviposition, from the time the female begins to hunt for a situable place to oviposit until the bud is cut, appears to be about thirty-two minutes. Mr. Theobald reports that in case of the apple blossom weevil, oviposition takes about three-fourths of an hour, so that in fine weather, when the blossom buds expand rapidly, a single female cannot lay very many eggs. The weevil is more injurious in England in cold and unfavorable weather because the opening of the buds is retarded. The same fact appears to be true of the strawberry weevil, as it is similar in habits. However, the weevil is most active in warm, sunny weather. The question remains, therefore, whether the weevil is actually more injurious in the short space of time, when the buds expand rapidly, or in the longer period of cool weather which retards the opening of the buds and the activity of the weevil.

Flight—Playing possum.—When disturbed, the weevil raises its antennae and stands still. If further disturbed, it drops to the ground and curls itself up. Upon being still further disturbed, it

slowly crawls away, but will sometimes take flight. Flight appears to be in a horizontal direction, the beetle having never been seen to fly upward. The distance covered varied from four inches to three feet. The males were observed to fly much more readily than the females.

Feeding habits in summer.—On June 16, 1915, four weevils that had emerged the day before, were confined in a wire cage over a strawberry plant. As the buds had all opened, they had nothing but leaves to eat. In a few days the lower epidermis of the leaves was found to be full of small, conspicuous round holes (Fig. 2, Pl. III), and one of the leaves that was badly eaten was drooping. Two weevils were found in a large cavity in a ripe berry where they had been feeding (Fig. 4, Pl. III). In the field, however, they do not attack the berries to any great extent, although a few of the late berries were found with holes characteristic of the weevil. It is fortunate that the weevils do not emerge sooner, as they might thus possibly be an important pest of the fruit as well. Some old weevils, also confined in a cage, made the same holes in the lower epidermis, but to a lesser extent. Recently emerged weevils, confined on June 28, were found to have cut a few buds, but no eggs could be found in them. On July 14, leaves with holes characteristic of the weevil were found in the field; while on August 11, in a field where the weevils were very abundant, the leaves were conspicuously dotted with tiny holes similar to one shown in the photograph. On very cloudy and rainy days the weevils rest quietly among the stems near the crown or beneath the buds. Sometimes they are found within the crown or on the ground near the crown.

The Egg.

Upon opening a bud, the egg is found to lie loosely among the anthers or against the petals, or upon the receptacle, a little to one side of the egg puncture (Fig. 3, Pl. I). About a day before the egg hatches, the mandibles can be clearly seen through the chorion, moving back and forth. The period required for an egg to hatch varies from three to nine days, depending entirely upon weather conditions, but averaging five or six days.

The Larva.

To free itself from the egg shell, the larva wriggles and contracts, pushing out its mandibles until it is free. One egg was observed to hatch on May 5. Upon hatching, the larva is whitish,

with a yellowish head, and dark colored mandibles measuring about 0.6×0.2 mm. The first food is the nutritious pollen, so that the larva grows rapidly. Later it attacks the petals, pistils, and receptacles. In about a week the larva measures 1.5 — 2 mm.×0.6 mm. At this time the head is of a light yellowish or greenish color with dark brown jaws. The body has a flaky appearance with creamy white spots mixed with orange red spots, forming a distinct brownish line on the dorsum. There is less red on the thorax and anal segments. Buds collected April 29 were found on May 20 to be entirely eaten out, nothing remaining but the sepals (Fig. 5, Pl. 1). The last thing to be eaten is the receptacle in which the larva makes a considerable depression. On all sides of the larva, and filling the bud, the shreds of excrement are to be found, some of which form a hard and tight cell about the larva, so that on opening a bud, the larva is not noticed until the cell is broken open. The length of the larval stage appears to be about three weeks. In the field on June 15, 1916, the larvae were from one-half to nearly full grown, while on June 19 many were full grown. At this latter date the first berries were being picked.

The Pupa.

The pupa undergoes its transformations in the pupal cell which is composed of excrement and constructed by the larva. When disturbed the pupa wriggles its abdomen violently, as if to protect itself. The length of the pupal stage appears to be about six days. In 1915 the pupae were not common in the field until July 1.

SEASONAL HISTORY.

Time of Appearance of Beetles in Spring.

The first buds found cut in 1915 were in a single uncovered row of old plants on April 20, while in 1916 none were found until May 17. The weevils apparently begin cutting the buds when the first blossom is about to open and the fruiting pedicels are about two inches long. Currants were in full bloom at the time. Many blossoms in that row were already open, being at least a week or ten days earlier than those that had been covered. On April 30, 1915, many of the buds in that row were cut and the weevils were found feeding and ovipositing in a nearly mature bud. This seems somewhat early for their appearance in Minnesota, but about two

weeks of warm weather brought them out of their hibernating quarters. In 1916, the beetles were observed on the plants on May 5, but no buds were cut.

From Emergence to Hibernation.

Throughout the whole month, excepting a few days, a period of cold, wet and rainy weather occurred, with two rather heavy frosts, May 9 and May 17, 1915. On the latter date, a heavy snowstorm occurred, but the larvae in the buds were not killed. By May 9, the weevils were fairly numerous on a two-year-old patch, although none were found on the new patches. On the same day cut buds of a wild strawberry plant were found. On May 12 buds were found cut in some of the new patches, while a great many were cut in the old single row. It appears that the weevils do most of their work after May 12. By May 17 they were present in great numbers and rapidly increased in the new patches. On June 2, 1915, the weevils were particularly abundant on a two-year-old patch, while on June 7, 85 per cent of the buds were cut. On June 19, 1916, 95 per cent of the buds in one patch were cut. Many buds of the red raspberry were found to have been cut on June 7, 1915, but blackberries near by were not harmed. On June 14 and June 20, 1915, the weevils were still cutting buds, while on June 30, 1916 (about the middle of the picking season), an egg was found. When picking had just been completed, July 11, 1916, an examination of the buds showed fifteen adults, nineteen pupae and five larvae. About 50 per cent of the buds contained nothing, the weevil had either emerged or been killed by parasites. Some weevils were yet present in the fields on August 11 on both strawberry and raspberry plants. No weevils could be found August 25.

Hibernation.

Concerning hibernation, Sherman, of North Carolina, wrote in 1904 as follows: "As yet it is impossible to say definitely just how and where the insect passes the winter. It seems certain that they winter in the adult stage, and it also seems certain that they hibernate around the edges of the field or in woods, but exactly where, whether in stumps, rotten logs, under brush, rubbish, and leaves, or under the surface of the ground, remains a question. Two whole days of careful search on March 9 and 10, looking under bark, sifting dirt, trash and pine straw, failed to throw any light on this question."

In New Jersey, Smith reported in 1911 as follows: "The results were not encouraging. Specimens in small numbers were found in almost all the places tested, but less in the strawberry fields themselves, than in the rubbish around the edges. They leave the strawberry fields after they mature, because they are more disturbed there than elsewhere and because it is too exposed and sunny in mid and late summer. For shelter any rubbish-covered, moist, protected locality will answer and nothing seems more attractive than the edge of wood or scrub land, if such is near by."

As the hibernating stage of the weevil is the most vulnerable point in its life history, a special effort was made to study that period in detail. At the beginning of the investigation, September 20, 1914, a whole day was spent in the fields digging in the ground and looking under stones to find the insect in the hibernating stage, but with no success. A similar unsuccessful search was made September 30, 1914. After a year, and with a better knowledge of the weevil's habits, the beetles were found hibernating on the ground around the crowns or beneath the dead leaves on August 25, 1915. When disturbed, they crawled slowly away. On October 1, the weevils were again found hibernating in large numbers among the dead strawberry leaves beneath the plants. About twenty weevils were found within a quarter of an hour, showing clearly that most of them are to be found in and among the dead leaves. By carefully examining a handful of dead leaves, four or five weevils were often found. They do not appear to be present under sticks or stones between the rows, but always well protected under the old leaves. Search was made around the edges of the field and within the woods near by, but no weevils were found. On April 18, 1916, the weevils were again found hibernating while winter covering was still on the plants. By removing the straw and examining the dead leaves carefully, six weevils were found in about thirty minutes. Some of the beetles were lying on the ground still dormant, while others were very slowly crawling about. On September 27, 1916, three dozen weevils were again found in half an hour, hibernating in about one square foot of space in a two-year-old patch where about 40 per cent of the buds had been cut the previous season. This particular patch was not burned over, although the weeds were mowed down. A search in an adjacent burned over and well-renewed field, but just as old, revealed only one weevil in twenty minutes. This patch was well cultivated, no dead leaves being present, and looked like a new patch set out the same spring. Whether the weevils were killed by the burning over,

or covered by dirt during cultivation, or migrated upon being disturbed, is unknown. On November 1, 1916, fifty weevils were found on the ground among the dead leaves in about forty-five minutes, in another two-year-old patch that had not been renewed or burned over. In an adjoining patch from which one picking had been made and which had been burned over, only one weevil was found in half an hour.

Another fact which would tend to confirm the fact that the weevils do not hibernate in the woods in Minnesota is that in May, 1916, the weevils could readily be found in the old patches and feeding on the leaves, while in the new fields even though they adjoined a woodlot, careful search failed to reveal their presence. The plants were equally mature in both fields, so that it is difficult to tell why they should not be present in equal numbers if they migrate from the woods in the spring.

That the weevils can pass the winter successfully in the strawberry patch was proved experimentally. During the summer of 1915 a wire cage about five feet long and three feet wide was placed in the field over strawberry plants among which several buds containing larvae were scattered. On May 20, 1916, the cage was removed, and the buds were found cut in much larger numbers under the cage than on the surrounding plants. The beetles, then, had no chance to migrate to the woods and none could come under the cage in spring, yet they passed the winter successfully even though no mulch was applied over the plants under the cage. The weevils, at least in Minnesota, hibernate within the strawberry fields and not in the woods, as was thought; although it is possible that a few might happen to migrate to the woods.

EXTENT OF INFESTATION.

After careful observation in many of the fields, it was found that the older the beds the more heavily infested they were. Plants are not usually attacked the first season, although some buds were found cut on May 30 in a newly-planted patch adjacent to an old infested one. It appears, therefore, that the weevils spread during the oviposition period. On a patch uncovered early and in full bloom by May 5, no weevils were found because it was set out the previous year.

A new patch of plants surrounded by grass land was found to be in almost perfect condition, only one or two buds being cut. In another field, on June 7, about 60 per cent of the buds were cut in a two-year-old patch, while on a new patch separated from

the others only by a small blackberry patch, little injury was shown. Many fields were visited and in all cases those beds from which the first picking was to be made were much less injured. This was beautifully shown in one particular field at Hopkins, where there were three adjoining plots, one, two and three years old, respectively. In plot one, where the first picking was being done, no trace of the weevil could be found. In plot two, one year older, where the second picking was being made, 25 per cent of the buds appeared cut. In the adjoining plot, number three, three years old, 90 per cent of the buds were cut. This is in accord with the hibernation habits of the adults, which winter over in strawberry beds.

INTERMITTENCE OF THE WEEVIL.

Mr. Chittenden remarks: "It is fortunate also that this weevil like so many other troublesome species is more or less intermittent in the character of its attack, appearing in great abundance for one or more seasons in certain districts and doing a vast amount of damage, and then without any apparent reason relapsing into comparative obscurity only to reappear after a number of years and in perhaps some new locality."

At Hopkins, the weevil has been destructive for the last three seasons and there is every indication that it will continue to be present. From a study of the hibernation habits, the intermittence of this insect may perhaps be explained by the fact that in some localities a farmer may have all old beds, which would be plowed up at the end of the season. As the beetles migrate slowly, the new beds would be comparatively free, because most of the weevils were probably killed by being plowed under the previous season.

Another factor is the character of the season, as discussed in a previous paragraph. In fine weather, when the blossom buds expand rapidly, the weevil is probably not able to cut so many buds because of lack of time. The following spring may be cold and rainy, and, having more time, the weevil may cause much more injury.

NATURAL ENEMIES.

To rear the parasites successfully, the buds must not be allowed to dry up, since the buds normally lie on the ground and remain moist. Two fern pots, one a little smaller than the other, answered the purpose very well. The smaller one is placed within the larger one so that the bottoms are opposite. The crevice is filled with

sand and a Comstock vial used in the opening to collect the parasites which come to the light. The fern pots are sunk in moist soil to keep the buds from drying out.

Mr. Chittenden reports four parasites for this insect, none of which was reared from this locality.

Several buds were placed in the breeding-jar on July 5. A total of 419 weevils was reared and 184 parasites, giving a total of 31.3 per cent parasitism. Two are new species, as reported by Mr. Girault, as follows:

CHALCIDOIDEA:

Eupelmus colcopterophagus N. sp. 5 ♀'s.
Catolaccus perdubius N. sp. 62 ♂'s and 45 ♀'s.
Habrocytus obscuripes Ash. 11 ♀'s and 28 ♂'s.
Polynema consobrinus Girault 1 ♂ and 3 ♀'s.
Eurytoma sp. 1 mutilated ♀.
One small encyrtid.
A few Proctotrypidae.

CECIDOMYIDAE:

Lestodiplosis sp. 14.

Midge larvae were occasionally found within the buds, July 11, 1916. The adults are a species of Lestodiplosis, as determined by E. P. Felt. Members of this genus are predaceous and possibly scavengers.

Lestodiplosis sp.—*Larva.*—1.8 mm. to 2.3 mm. long; orange-red; somewhat flattened and tapering toward head end. The mouth parts are prominent. Ventral surface of each abdominal segment covered with small tubercles and with two hairs projecting from each.

A small black dipteron was also reared from the buds and named by Aldrich as *Elachiptera costata* Loew.

Out of 162 buds examined July 1,

56 contained nothing,
61 contained weevil larvae,
46 contained parasites,

giving 43 per cent parasitism of the buds which contained larvae. Parasitic larvae were not numerous until June 20, while on July 8, being about the end of the picking season, the adult parasites were emerging in large numbers from the insectary pots. Some emerged even on July 25. In a few instances hyperparasitism was observed. Ordinarily, when a bud is opened, the larva strikes violently back and forth. If, however, it is parasitized, it will remain motionless,

although it may look healthy, and apparently free from parasitic larvae. Examination usually reveals the small larvae on the body, sucking the juices. In some cases only eggs of the parasites were found on or near the weevil larva, yet it already appeared dead.

Many of the buds (about 10 or 15 per cent) do not fall, but remain hanging. These are quite conspicuous because they turn brownish when dry. Upon examination, about 50 per cent of them contained larva, while in the others nothing was found, probably owing to their having dried out. Many of the buds, upon falling to the ground, are so covered with leaves that they remain very moist, and although in some instances fungus threads were found in the bud, the larva was apparently very healthy, showing that it can withstand very moist conditions. This was further substantiated by the fact that a larva, upon hatching, lived for four days in water.

REMEDIAL MEASURES.

Professor Headlee (1916) summarizes the control measures recommended for the strawberry weevil, and points out that they are inadequate to meet the demands of practical growers or are impractical in other ways.

Effect of Burial of Adults.

Since the adults hibernate within the fields, and since the old fields must be cultivated to be renewed properly, it is of considerable importance to know the effect of burial on the adults. Laboratory experiments were conducted by putting adults and buds containing weevils in the bottom of three-inch pots, and covering them with two inches of soil. The pots were watered after burial and covered with cheesecloth. Five days later, the weevils were alive at the bottom of the pots; two weeks later they were dead, most of them at the bottom of the pots, although a few appeared to burrow upwards as much as one-eighth of an inch. This experiment indicates that the adult weevil has little ability to emerge when covered with soil, and this appears to be substantiated under field conditions, for in a bed that was thoroly renewed and cultivated only one weevil was found in the field on November 1, while in an adjoining field that was not a renewed one, fifty weevils were found. Furthermore, the burial of the adults as a means of control can be accomplished by plowing under the old infested beds. Since the weevils do not fly, but fall to the ground on the slightest disturbance, they, as well as the larvae, can all be destroyed by plowing them under soon after picking the strawberries.

Insecticides.

Powdered lead arsenate and sweetened liquid lead arsenate were tried out on a small scale as the weevils began to appear, but with no apparent results. Spraying with a stomach poison appears useless during the egg-laying season, for at that time the weevils feed principally on pollen, which, as was found in the case of the cotton boll weevil, is absolutely necessary for the formation of eggs. However, the old hibernating weevils, as well as the new brood upon emerging in the summer, feed on the under side of the leaves before the pollen is mature. But the problem remains, how to get the poison on the under side of the leaves of such a low-growing plant as the strawberry.

Professor Headlee of New Jersey reports the successful use of a sulphur-arsenical dust experimentally as a repellent. Two experiments under practical conditions were, therefore, conducted in fields where the weevils were abundant, by two different farmers. Equal parts of sulphur and powdered arsenate of lead were applied with a powder gun on May 20, when about 8 per cent of the buds were already cut. On May 21 and 23 it rained. The material was again applied on May 25 and May 30, and it rained again the next day. Most of the material was washed off and since the material acts as a repellent no apparent results were obtained. On May 30, about 50 per cent of the buds were cut in one of the fields, and the weevils were present in the beds, while on June 16, 96 per cent of the buds were cut. In the other field that was sprayed the weevils were not so abundant, but they were present on the raspberry buds, which they were cutting. They may have been driven over by the spray. In spraying an old bed, the weevils may also be driven to the new beds. Because of the rainy spring weather and prolonged blossoming season in Minnesota, and because only the older beds are severely injured, spraying with a repellent will not be entirely successful. However, the sulphur-arsenical dust deserves further trial.

Fencing.

As the weevils do not fly very far or very high, it seemed possible to keep them out of new beds by means of a fence. A wire screen fence about two feet high was erected April 30, 1915, around a plot of ground about ten feet square. This was banked up with dirt around the bottom, and boards placed on top of the wire. Tanglefoot was then smeared on both sides of the boards to determine if the weevil would attempt to fly or crawl in. No weevils

were found in the tanglefoot and none were observed on the fence. Buds were not found cut within the enclosure until June 20, when most of the blossoms had already opened.

Covering the Beds.

Covering the beds with light muslin, as advised, was found unsatisfactory. The berries did not ripen so early, and in fact the plants were in poorer condition than in the check plot. The muslin had to be kept on more than five weeks because the cold rainy spring prolonged the blossoming season.

Cropping Systems.

The one-crop system.—Since the weevil passes the winter in the strawberry beds, at least in Minnesota, and does not disperse readily, the older beds are more severely infested than the newer ones. It follows, therefore, that severe injury may be avoided by using the one-crop system. This fits in with the general methods of controlling the insect pests of strawberries as noted by Crosby in his book on Fruit Insects.

"Strawberry growing is more akin to the raising of field crops than to the cultivation of other fruits. Likewise in the control of strawberry insects, less reliance is placed on spraying and more attention is given to crop rotation. The one-crop system of strawberry culture as now practiced by the majority of commercial growers, greatly simplifies the problem of insect control."

Professor A. E. Wilkinson writes as follows in his book on "Modern Strawberry Growing."

"Generally a grower will practice rotation of crops, taking but one crop from his bed and setting out another on an entirely new piece of land, believing that what little saving there may be in renewing the old bed will be greatly counterbalanced by the larger size of the fruit, freedom from insect pests and diseases, and better physical and chemical conditions of his soil."

In addition, the beds do not get weedy under the one-crop system and a crop of fodder corn may be obtained. The beds should be plowed deeply immediately after picking, to bury the weevils and larvae in the buds. It would also be advisable in replanting to select plots as far away from the old beds as possible, since the weevils do not migrate rapidly. This is difficult on the six or seven-acre farms at Hopkins, and is one reason why the weevils are abundant. Where the weevils are particularly abundant the one-crop system should be practiced until their numbers are considerably diminished.

The two-crop system.—The one-crop system does not appeal to many of the farmers who have been accustomed to two or more crops from the same bed. Much of the injury from the weevils can be avoided even where the two-crop system is practiced by thoroughly burning over and renewing the bed. As soon after picking as possible, the beds should be mowed, and when dried out, a thin layer of straw should be spread over the bed and the patch burned over. After this operation, the beds ought to be well cultivated all over and the rows narrowed to about one foot. The aim should be to make the bed as clean as a new field. All the dead leaves, weeds, and other rubbish, all of which make suitable hibernating quarters for the adults, will thus be removed. Under field conditions, it was difficult to find a single weevil where the beds were burned over and cultivated. Wilkinson remarks that burning over is advantageous for the following reasons:

1. The bed is left clean;
2. The insects and diseases are killed or controlled;
3. The bed, being clean, is easier to work.

More than two crops ought never to be taken from the same field, and old neglected patches should not be tolerated, since they serve as breeding grounds.

Summary.

1. In Minnesota, the adult weevils make their appearance the latter part of April or early in May, feeding on the under side of the leaves until the pollen is mature.

2. The buds are first cut as soon as the first blossom shows and the fruit pedicels are about two inches high.

3. Fields with from 40 to 95 per cent of the buds cut were not uncommon.

4. The new brood emerges soon after picking, eating small holes on the under side of leaves.

5. Hibernation began the latter part of August, in 1915, among the dead leaves in the strawberry patch.

6. The weevils pass the winter in the strawberry beds and not in the woods, at least in Minnesota.

7. Old beds are more severely infested than younger ones.

8. The natural enemies reared were five species of Chalcids and one Cecidomyid.

9. The indications are that the weevils are not able to emerge when plowed under or covered with soil during cultivation.

Control Measures.

10. The one-crop system.—Since the weevils hibernate within the fields, the one-crop system will prevent severe injury. Badly infested fields should be plowed under immediately after the berries are picked.

11. Where the two-crop system is practiced the beds should be burned over and thoroughly cultivated.

12. Old, neglected patches should not be tolerated.

13. The weevil will probably not be serious on the Everbearing strawberry.

14. Covering the beds with muslin or spraying with poisonous arsenicals was not satisfactory.

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Compiled notes on methods of control. In 1899 a patch of wild blackberries near the college had 182 out of 291 buds destroyed.

Chittenden, F. H.
1903 U. S. Department of Agriculture, Division of Entomology, Bul. 40: 120.
Injurious at Rose Hill, Wilmington, and Baltic, N. C., Byrneville, Ind., Van Buren, Ark.

Chittenden, F. H.
1898 Notes on the strawberry weevil, U. S. Dept. of Agr., Div. of Ent. Bul. 10, N. S.; pp. 82-87.
Its injuries and bibliography. Correspondents report apparent success with Bordeaux and Paris green; clean cultivation and use of tobacco dust and fertilizers.

Close, C. P., and Ballard, W. L.
1911 Maryland Agricultural Experiment Station; Bul. 160: 220.
Advises clean cultivation and profusely blooming varieties.

Fletcher, J.
1906 Report of the Canadian Experimental Farms for 1905, p. 187.
Report of injury at Clarkson, Ontario. Advises pistillate varieties; trap crops near outer rows. Covering of plants was found to keep out bees that aid in fertilization.

*Fletcher, J.
1899-1900 Transactions of the Royal Society of Canada, 2nd ser. 5, pp. 207-231.

Headlee, T. J.
1915 New Jersey Experiment Station report of the Entomological Dept. for 1914, p. 349.
More injurious than usual. Fifty per cent loss reported often. Manhattan variety especially susceptible. Pistillate varieties not in favor by farmers.

Headlee, T. J.
1916 New Jersey Agricultural Experiment Station; Cir. 56.
Experiments with a mixture of sulphur and arsenate of lead powder reported successful against the strawberry weevil as a repellent.

Herrick, G. W.
1912 Lime and the strawberry weevil, Rural New Yorker, July 13, p. 781.
Lime, ashes, dissolved bone, kerosene and plaster, and tobacco dust found wanting. Some growers report success with arsenate of lead.

Hitchings, E. F.
1906 Maine Experiment Station First Annual Report of the State Entomologist.
Plants imported from New York found infested with the weevil and destroyed.

Houghton, C. O.
1904 Delaware Experiment Station Report for 1903, p. 158.
Brief report. Found practically no weevils at Bridgefield where they were abundant the previous year. Slight injury to strawberries of Mr. C. A. Betts, of Cannon, Del.

Johnson, W. G.
1897 U. S. Dept. of Agr., Div. of Ent., Bul. 20: 64.
Reported injury to Enhance and Lovett varieties from Allegheny Co., Washington Co., Blue Ridge Mts.

Lockhead, W.
1908 Annual Report of the Entomological Society of Ontario 39, pp. 124-125.

Lugger, O.
1899 Minnesota Experiment Station Fifth Annual Report of the Entomologist, p. 199.
Found in limited numbers in state. Compiled notes on life history and control.

Morril, A. W.
1907 The strawberry weevil in the South-Central States U. S. Dept. of Agr., Bur. of Ent., Bul. 63; 57-62, part 6.
Parasitism studied in connection with *Anthonomus grandis*, 10-15 per cent of buds injured in Arkansas where parasitism was indicated.

Murtfeldt, M. E.
1900 Some insects injurious to small fruits. Report Missouri Horticultural Society, p. 318.
Compiled notes on life history and habits. Advises use of Paris green.

O'Kane, W. C.
1914 Injurious insects; how to recognize and control them, p. 337.
Recommends early spraying with lead arsenate and Paris green; also clean cultivation, burning over, and the use of pistillate varieties.

Patch, E. M.
1907 Maine Agricultural Experiment Station. Bul. 148: 271.
Found to be widely distributed, although but a single large strawberry crop was destroyed, near Farmington. The weevils were also collected on wild raspberry.

Pettit, R. H.
1906 Michigan Agricultural Experiment Station. Bul. 244: 104.
Economic notes. Advises clean culture, trap crop of staminate varieties, arsenate of lead. Blackberries found badly infested at Arcadia.

Quaintance, A. L.
1905 Entomological Notes from Maryland. U. S. Dept. of Agr., Div. of Ent. Bul. 40: 49-50.
Reports 25-50 per cent injury—profusely blooming varieties proved satisfactory in escaping loss. Pistillate varieties not found satisfactory.

Quaintance, A. L.
1897 The strawberry weevil. Florida Agricultural Experiment Station. Bul. 42: 597.
Does not occur in Florida, but mentions its possible introduction.

Sanderson, E. D.
1913 The strawberry weevil. Insect Pests of Farm, Garden, and Orchard, p. 456.
Advises pistillate varieties, trap crops, spraying with arsenate of lead, clean culture.

Sanderson, E. D.
1903 Delaware Experiment Station Report of the Entomologist for 1902, p. 150.
Reported as injurious since 1898 at Bridgewater, especially noticeable on pistillate varieties and near woods. Suggests burning over of fields.

Sanderson, E. D.
1902 U. S. Dept. of Agr., Div. of Ent., Bul. 37: 102.
Reported as excessively injurious since 1898, ruining crop in some places. Considers a remedy for this pest of great value.

Sherman, F., Jr.
1909 Notes of the year. Journal of Economic Entomology, Vol. 2; 201-206.
Reported as again serious; pistillate varieties not popular because they are not early enough.

Sherman, F., and Collet, R. W.
1904 N. Carolina Department of Agr., Div. of Entomology, Circ. 12.
Notes on appearance, life history and habits. Recommends the planting of imperfect varieties, the mowing and burning of fields immediately after picking, clean culture, trap crops, and spraying with Bordeaux and Paris green. No results were obtained with carbolic acid, and water, and whale oil soap.

Slingerland, M. V., and Crosby, C. R.
1914 The strawberry weevil. Manual of Fruit Insects, p. 372.
Recommends pistillate varieties, trap crops, spraying with arsenate of lead, clean cultivation.

Slingerland, M. V.
1908 Fighting the strawberry weevil, Rural New Yorker 67: 804.
Recommends covering the beds with muslin, cultivation of pistillate variety, trap crops, and combination of arsenate of lead, and Bordeaux mixture.

Smith, J. B.
1911 N. J. Agricultural Experiment Station Report for 1910, p. 308.
Hibernation habits studied. Fewer specimens were found in the strawberry fields than in the rubbish around the edges. Not abundant in any one place. Woods or scrub land near by seems more attractive than any rubbish covered or moist protected locality.

Smith, J. B.
1912 N. J. Experiment Station Report of the Entomologist for 1911, p. 412.
Reports injury in Burlington, Camden and Gloucester Counties. Mr. Blake working on a resistent variety.

Smith, J. B.
1909 N. J. Agricultural Experiment Station. Insects Injurious to Strawberries. Bul. 225.
Life history, habits and control measures. Recommends Bordeaux and Paris green. Just before blossoming (4 lbs. of copper sulphate, 4 lbs. of lime, 50 gals. H_2O with 1 lb. of Paris green or 5 lbs. of arsenate of lead to every 125 gal. of Bordeaux); also mowing and burning of vines as soon as picking is over, covering of beds, pistillate varieties, clean culture, trap crop and profusely blooming varieties. Does not advise mulching.

Smith, J. B.
1905 N. J. Experiment Station Report of the Entomologist for the year 1904.
Notes prevalence. Abundant in Atlanta Co. and Southern States.

Smith, J. B.
1903 N. J. Experiment Station Report of the Entomologist for 1902, p. 429.
Reported as injurious in Burlington and Cumberland Counties.

Smith, J. B.
1898 N. J. Experiment Station Report of the Entomologist for 1897, p. 402.
Report of injury.

Symons, T. B.
1904 Entomological Notes of the Year in Maryland. U. S. Dept. of Agr., Div. of Ent. Bul. 46: 97.
Report of injury.

Washburn, F. L.
1904 Minn. Expt. Station. Ninth Report of the State Entomologist, pp. 52 and 78.
Advises spraying with Bordeaux and Paris green; burning over of fields; planting of pistillate varieties.

Washburn, F. L.
1903 Eighth Report of the State Entomologist, p. 151.
Report of injury. Advises the planting of pistillate forms.

Webster, F. M.
1902 U. S. Dept. of Agr., Div. of Ent. Bul. 31:85.
Very injurious in Scioto County, Ohio. Half of crop destroyed.

Webster, F. M.
1901 Report of Committee on Entomology, Ohio Horticultural Society, Report of 1901, p. 878.
Reported as injurious near Scioto and Portsmouth, Ohio, at the farms of Mr. Walters and Mr. Kenney. 50 per cent of crop destroyed.

EXPLANATION OF FIGURES.

Figure 30. (Plate 1.)

Fig. 1. The Strawberry Weevil: Side view of the adult.
Fig. 2. The Strawberry Weevil: Dorsal aspect of the adult. (Enlarged about seven times.)
Fig. 3. Bud opened, showing egg in position.
Fig. 4. (Right.) Egg just before hatching, showing mandibles.
(Left.) Young grub just after hatching from the egg.
Fig. 5. Bud opened, showing the mature curved grub with the pollen and the contents of the bud eaten out.
Fig. 6. Pupa.
Fig. 7. A dried strawberry bud showing the emergence hole of the adult.
Fig. 8. Antenna of the adult (greatly enlarged).

Figure 31. (Plate 2.)

Fig. 1. The Strawberry Weevil in the act of cutting bud in which it had oviposited.
Fig. 2. Raspberry buds cut by the weevil.
Fig. 3. Pedicel of a strawberry plant, showing all of the buds cut off by the weevil.

Figure 32. (Plate 3.)

Fig. 1. Leaf of strawberry, showing feeding punctures on the under side made by the hibernating weevils in the spring soon after emergence from hibernation.
Fig. 2. Leaf of strawberry, showing feeding punctures made in August by the new brood, before going into hibernation.
Fig. 3. Strawberry leaf with parts fallen out where the feeding punctures were close together.
Fig. 4. Work of the weevil on fruit.

Figure 33. (Plate 4.)

Fig. 1. Ventral aspect of the mouthparts of the adult. (S) Submentum. (L) Labium. (M) Maxilla. (M'd) Mandible.
Fig. 2. Dorsal aspect of mouthparts of larva. (L.p.) Labial palpus. (M.p.) Maxillary palpus. (L) Labium. (S) Stipes. (M) Mandible.
Fig. 3. Ventral aspect of the maxilla. (M.p.) Maxillary palpus. (L) Lacinia.
Fig. 4. Ventral aspect of the labium. (L.p.) Labial palpus. (M) Mentum.
Fig. 5. Ovipositor as dissected out.

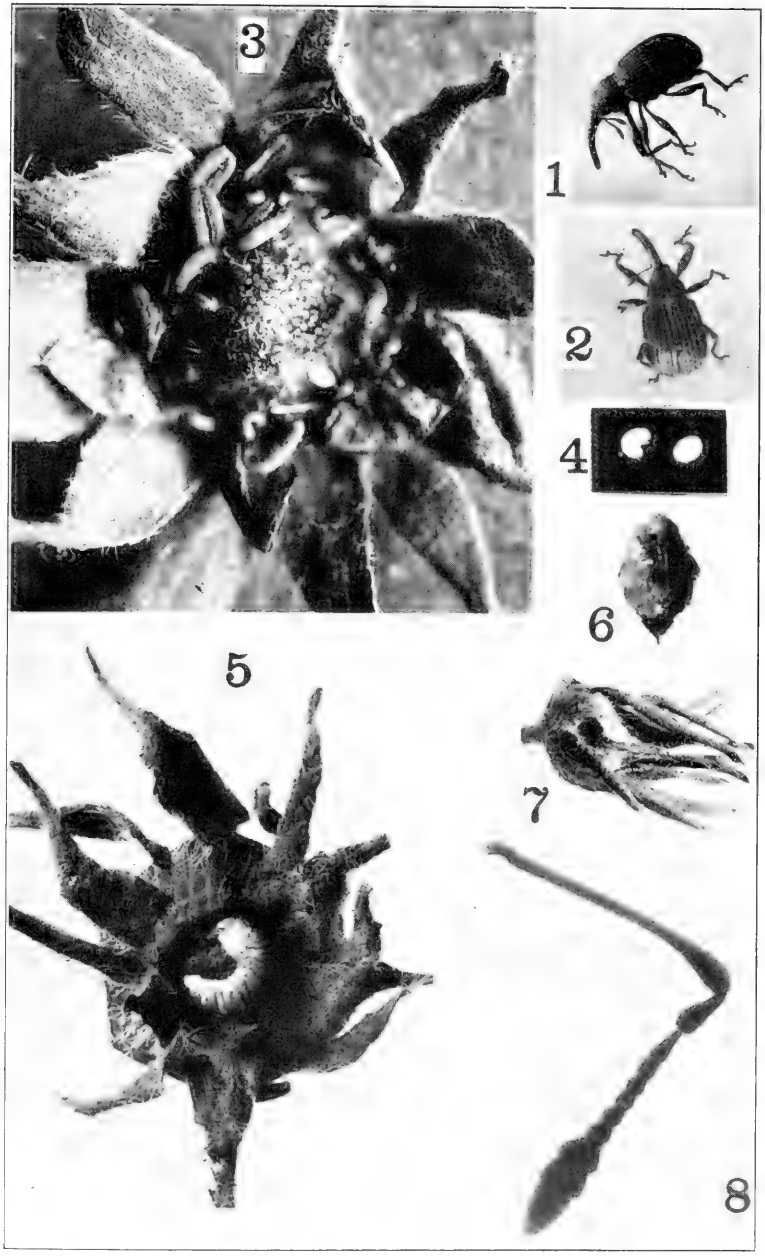


Figure 30. (Plate 1.)

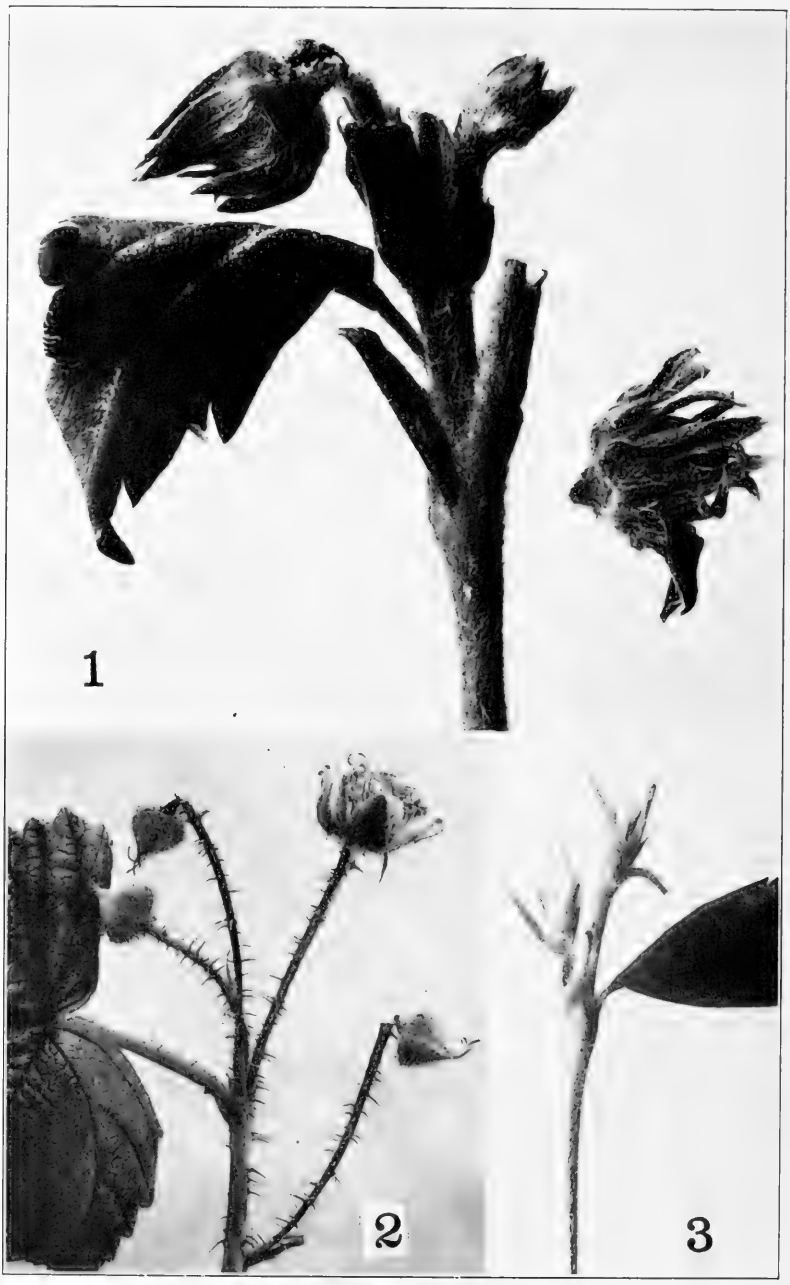


Figure 31. (Plate 2.)

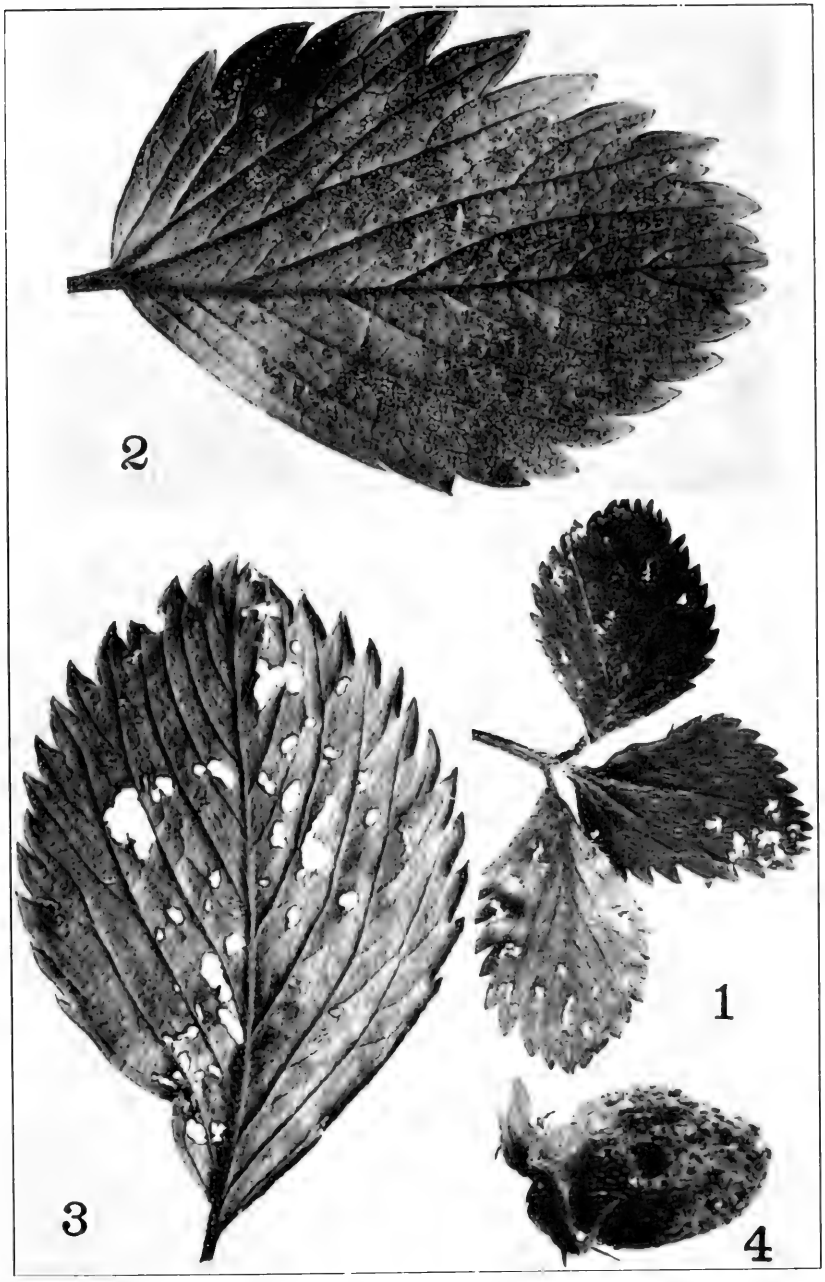


Figure 32. (Plate 3.)

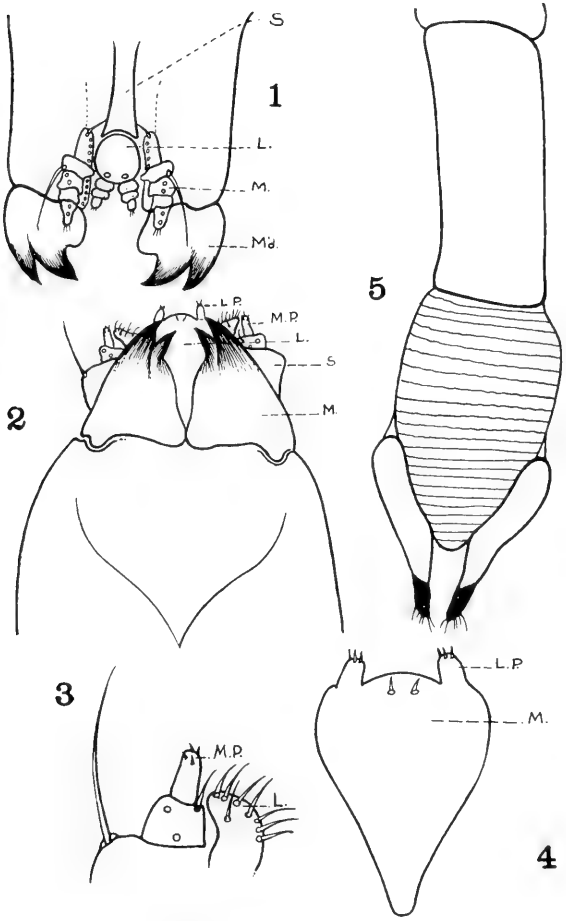


Figure 33. (Plate 4.)

INSECTS ATTACKING WEEDS IN MINNESOTA*

S. MARCOVITCH

The growing of crops has been aptly called a fight against weeds. Weeds are so closely associated with the farm economy that a knowledge of the weed-infesting insects is highly desirable. When seen from its various phases, the subject is extremely complex, so that it is sometimes difficult to tell where the usefulness of an insect begins and where it ends.

Certain insects are so closely adapted to particular weeds that they will always remain with them, and are undoubtedly useful. For example, the midge, *Dasyneura gibsoni* and the fly, *Trypeta ruficanda*, so completely destroy the seeds of Canada thistle that it is sometimes difficult to obtain good seed. Such insects are just as beneficial as our seed-eating birds; and considering the great number of insects, their value cannot be overestimated. As is well known, weeds are widely distributed through the agency of man. Their seeds are transported with the crop seeds, thus becoming established in new localities. Such weeds may become even more troublesome in their new situations, because their insect enemies were left behind. Moreover, if we had a complete knowledge of the weed insects, it might be possible to establish certain insects which are known to attack weeds, in parts of the world where those weeds or their relatives occur, but the insects do not.

As this paper is about to go to press, an interesting note appears in Science N. S. Vol. XLV:380, indicating the practicability of importing insects for such purposes. Mr. Jarvis, Assistant Entomologist of Queensland, made a trip to Hawaii for the purpose of gathering the lantana Agromyzid which very successfully prevents the seeding of this most troublesome weed in Hawaii. This agromyzid was introduced into Hawaii by Br. Koebele, who it will be remembered was responsible for the successful introduction of the Australian ladybird *(Novius cardinalis)*, the imported enemy of the fluted scale. As many of our worst insect pests have been introduced accidentally, it is also probable that some beneficial importations were likewise introduced. According to Hyslop, Jour. Econ. Ent. Vol. X:278, *Ceutorhynchus marginatus* Schonh appears thus to have been introduced accidentally. Its host plant is the noxious

*This study was undertaken at the suggestion of Professors William Moore and W. L. Oswald. I am greatly indebted to Professor Oswald for the determination of the plants and co-operation during the progress of the work. I also wish to thank Messrs. Busck, Aldrich and Pierce of the Bureau of Entomology for the identification of many of the insects.

dandelion *Taraxacum officinale* Web., the seeds of which it generally infests, destroying approximately one-quarter of them.

From my own observations of the weed insects in Minnesota the Milk Vetch *(Astrogalus canadensis* L.) is very probably kept from being a noxious weed of the first order by its insect enemies, four species of which almost completely destroy the seeds.

On the other hand, weeds harbor many of our insect pests and are often undoubtedly the starting point of insect outbreaks. Sanderson includes crop rotation, fall plowing, clean culture, as well as weeds among his farm or cultural methods for controlling insects, which practices are beginning to be recognized as of increasing importance in farm economy, especially in case of the field-crop insects where spraying is impracticable. It is well known that many insects feed on weeds during the early part of the season until the cultivated crop is available, as, for example, the corn root aphis. This louse maintains itself on young smartweed and foxtail grass at first, and if corn is not planted, it will feed, according to Forbes, on puslane and pigeon grass.

Many of the beetles that feed on solonaceous plants also get their start in spring on weeds of the same family. The strawberry flea-beetle is said to deposit its eggs on the evening primrose, its only other food plant. Obviously, such a weed should not be tolerated near strawberry beds.

The dominant tarnished plant bug, a well-known, formidable pest, has a wide range of food plants, including such weeds as golden rod, aster, daisy, fleabane, wild carrot, and mullein.

The common evening primrose beetle, *Tyloderma fovcolata* was reported in 1897 as very injurious to strawberries in British Columbia. This species is not generally known as a pest of strawberries; but a closely related form, *T. Fragaria,* is familiar to many as the strawberry crown borer. An attempt was made to find out whether *T. fovcolata* would attack strawberries in Minnesota. Four wire cages with strawberry plants were used and beetles placed in them throughout the season. The beetles were taken from the evening primrose during their oviposition period, and while they fed on the leaves and pedicels voraciously, they failed to oviposit in the crowns. It appears then that we have nothing to fear from this insect in Minnesota. In fact, it ought to be considered useful, in that it helps to destroy weeds.

Similarly the common knotweed leaf beetle, *Gastroidea polygoni,* found feeding on wild buckwheat *(polygonum convolvulus)* which is related to buckwheat, was also tested. Altho the beetles

eat the leaves and deposit eggs on the buckwheat, it will probably never be a serious pest, since buckwheat is such a fast-growing plant. Under favorable conditions, however, it is easy to see that it may be a pest.

Furthermore, the spinach leaf miner maintains itself on lamb's quarters, while the cabbage maggot lives over on wild mustard. While such insects are useful, in that they help to destroy these weeds, they are also very injurious because they are not confined to one host plant. Furthermore, an insect that appears quite harmless, and confined to a certain weed may, if a near relative of its host plant is cultivated, become very injurious. Such possibilities are becoming more in evidence, especially since hundreds of foreign plants are being tried out by the United States Department of Agriculture, with a view to adapting them to our needs and conditions.

The subject is also interesting from an ecological point of view. According to Shelford, the original habitat of our native pests and the places that support the majority of them, are the forest edges and thickets, made up largely of rank weeds. The above situations offer ideal conditions for the breeding of many of our native pests and with the destruction of the forests, the building of roads, railroads, and the presence of the farm woodlot, the thicket formation is greatly increased. In fact, the author was in the habit of visiting just such places for this study because weeds were there found in abundance.

In this connection it might be well to mention that a knowledge of our weed insects would be very useful to the teacher. Often it happens that even in midsummer it is difficult to get illustrative material for class use, because the insects have been controlled in the cultivated plants or are not present for some other reason. Weeds, however, are always present, together with their insect fauna, and if one knows where to look, he is sure to be rewarded. The little purslane saw-fly, for example, is generally abundant all summer.

Finally, a knowledge of our weed insects will help to make the natural history of our state better known. In his classic reports, Riley devoted a portion of them to what he calls innoxious insects, many of which attack weeds.

In this paper I have confined myself only to the insects of the herbaceous weeds, although the wild cherry could be considered a weed, since it harbors many orchard pests. An attempt was made to get the breeding habits, and especially the location of the larva,

and the life history if possible. The Diptera Lepidoptera, and Coleoptera were given special attention, while the Hemiptera were almost neglected.

The subject is, therefore, a very complex one and only a complete knowledge will help us to solve some of the difficulties. The author realizes that he has made only a beginning; it is hoped, however, that it will stimulate others to carry on the subject.

CURLED DOCK (*Rumex crispis* L.) Insects.

The Curled Dock Leaf-miner (*Pegomyia bicolor* Weid).

These larvae were commonly found on June 3, making large blotch mines, especially in the lower leaves. One larva pupated on June 15, the adult having emerged on July 8. Two to six eggs are laid on the under surface of the leaves.

Egg.—Length 1.1 mm. by 3/10 mm. wide. Color, dull white. A polygonal sculpture visible on the surface. One end of the egg is rounded, while the opposite end tapers to a point.

Mantura floridana Crotch?

The larva of a small brownish flea-beetle were found mining in the leaves on June 23, but they were not common. Adults emerged on July 4.

WILD BUCKWHEAT (*Polygonum convolvulus* L.) Insects.

The Knotweed Leaf Beetle (*Gastroidea polygoni* Linn).

These beetles were first observed on the plants ovipositing on August 4. The yellowish eggs are laid in a mass on the under side of the leaves, each one being about one mm. in length. The eggs were hatching on August 8, the young larvae devouring the leaves greedily. The females have the abdomen very much swollen, are about 4½ mm. in length, with head and elytra green, while the thorax and legs are reddish.

Since the weed on which it was found belongs to the buckwheat family, an attempt was made to rear them on the cultivated buckwheat. The adults, as well as the larvae, eat the leaves, and deposited eggs. Altho this species is not a pest of buckwheat, it is possible that it might be. However, there is little chance of serious injury because the buckwheat is such a thrifty grower.

LAMB'S QUARTERS *(Chenopodium album* L.) Insects.

The Spinach Leaf Miner *(Pegomyia hyoscyami* Panz).

This species is a pest of spinach, and other Chenopodiaceae, such as lamb's quarters. It is also recorded as breeding in *Amaranthus retroflexus,* altho I have been unable to find them here. The species until recently has been known as *P. vicinia,* but Cory and Knab have shown it to be a synonym of *P. hyoscyami,* an European species (Jour. Econ. Ent., June, 1916). In this paper, a detailed account is given of the insect. In Minnesota, the larvae were first observed the latter part of May and early June, while one adult was reared on June 28. There are probably three broods during the season. The egg is nearly one mm. long by 3/10 mm. wide. It is whitish in color with one end rounded and the opposite end truncate. Surface with a polygonal reticulation. The eggs are deposited on the under surface of the leaf, generally three or four in a row.

Gnorimoschema artimisiella Kearfott.

I have called this species the wormweed web worm, having reared it first from Artimesia. I have also found it mining in sunflower leaves and tying the terminal leaves of *C. album.* The small larvae about ⅜ inch long were observed in June. Pupation occurred on July 7 and one adult emerged on July 14.

PURSLANE *(Portulaca oleracea* L.) Insects.

The Purslane Saw Fly *(Aprosthena zabriskei* Webster and Mally.)

This very interesting little leaf miner occurs wherever purslane is found. The full-grown larvae are nearly ½ inch long, greenish, and make large blotch mines. Adults may be found flying about the plants from June to September. The eggs are deposited in the edges of the leaves, causing small blisters which appear slightly elevated and somewhat lighter than the surrounding tissue. These swellings measure about 4/5 mm. long by 3/5 mm. wide. There appear to be several generations, for it takes only from seven to ten days for the larvae to transform. The adults are black, about ¼ inch long, the male having forked antennae. Being abundant all summer, this species could be used to advantage for study and breeding purposes in schools.

The natural enemies reared were one larval parasite *(Ichneutidea secunda)* and two egg parasites. The former is yellowish

and nearly as large as the adult host. The egg parasites, as determined by Girault, are *Anaphoidea conotracheli* Girault and *Achrysocharis kansensis* Girault. These emerged July 27. An account of this saw fly is given in the Canadian Entomologist, 1900, page 51.

PARTRIDGE PEA *(Cassia chamaecrista* L.) Insects.

The Partridge Pea Weevil *(Bruchus cruentatus,* Horn).

The weevils, together with larvae, were present during the fall in the seed pods brought in by Professor Oswald.

PRAIRIE CLOVER *(Petalostemum purpureum* (Vent.) Rydb.) Insects.

The Prairie Clover Weevil *(Apion varicorne* Smith).

The beetle was found quite common on the flowers of this plant, June 18. The larvae are very small, legless, being about 1.5 mm. long. They were present in the head towards the center during August. Pupation took place August 17, while adults emerged on August 24. The species is also recorded on the flowers of huckleberry and the flower heads of *Perosela aurea.*

MILK VETCH *(Astragalus canadensis* L.) Insects.

The Milk Vetch Weevil *(Bruchus schrankiae* Horn).

Over-wintering in the pods of this weed, may be found small, pale, yellowish larvae in light cocoons. The first adults in the field were observed July 5. There are probably two broods present.

The Milk Vetch Snout Beetle *(Tychius arator,* Gyll., Schön.).

This species appears not to have been recorded from any food plant before. The adults were common about the plants on July 5, ovipositing their eggs within the pods. Pupation was observed on September 8, and on September 28 adults emerged. The larvae build a light brownish silken cocoon, while the adults are grayish-black, about 3 mm. in length, and clothed with dark clay-yellow scales.

Phycid Sp.

On July 5, greenish larvae, about 5/8 inch long, with a black head, were found tying the leaves to the immature pods. The larvae build grayish silken cocoons when ready to pupate, one adult having emerged on July 15. The moth is whitish with a black line across the middle of the wings.

Phorbia Sp.

Occurring very abundantly in the pods on August 30 were dipterous larvae. These are very voracious, for they consume most of the seeds. The pods turn brownish when infested by the maggots, which make conspicuous exit holes when full grown. I did not succeed in rearing the adults, but those of *Phorbia* sp. were present about the pods on July 12th and may be the parent form.

There is no doubt but that these insects infesting the pods destroy most of the seeds and help to keep this weed in check.

EVENING PRIMROSE (*Oenothera biennis* L.) Insects.

The Evening Primrose Beetle (*Tyloderma foveolata*, Say).

This species was reported in 1897 as very injurious on strawberries in British Columbia, the grubs attacking the crown similarly to *T. fragaria* and breeding also in willow herbs. Webster records its oviposition habits similar to that of *T. fragaria*.

Oviposition.—After finding a suitable place, the female bores a small hole in the stem with her snout. She then turns around and places an egg within the cavity; after the egg is laid, the female proceeds to cover it up, resting directly over the egg, and remaining in this position without moving the feet until the process is completed. About ⅛ inch away from the egg a shred of tissue is taken up with the beak and carefully placed over the egg. This is repeated many times until the egg is completely covered, when the female turns around and begins the same operation at the opposite end. Oviposition lasts about 25 to 30 minutes, and when completed, a conspicuous scar is left on the stem. Such a scar will measure about 6 mm. long and 4 mm. wide, the central portion of which is somewhat elevated and brownish, while above and below, shallow cavities exist. These scars may be made anywhere on the stem from the bottom to the top, and as many as 30 or 40 may be present.

Life History.—The beetles were first observed on June 7, ovipositing and making their scars on the stem. Egg, larvae, and adults may be found throughout the greater part of the summer. On August 29, pupae were already present within the stem, while a few days later, adults emerged. There is one generation a year and the winter is passed in the adult stage.

Pupa.—Whitish, except eyes in mature pupa. Four large bristles on snout, and four on the head, all of which are arranged in two longitudinal rows. Anterior margin of thorax with four

bristles and two transverse rows of bristles which arise from prominent tubercles on rest of the thorax. Tip of the abdomen with a large stout spine on each side.

Larva.—Length, about 5 mm. x 2 mm. wide. White in color except head, which is yellowish. Mandibles with two teeth the lower one the larger, and dark brown. Labrum somewhat wider at the base with bristles in front and with two longitudinal black lines. Antennae very minute, one-jointed. The following parts of the head are darkest; tip and base of mandibles, spots near upper corners of clypeus and circular spot just laterad of the antennae. Head with a few rows of slender hairs. Body strongly curved and covered with very short sparse hairs. The venter of the thorax has three fleshy lobes, each of which bears several hairs.

Egg.—Length, 4/5 mm. x 3/5 mm. wide. Greenish or brownish; shape elliptical; chorion very dense and smooth.

The Evening Primrose Bud Caterpillar (*Mompha stellela*, Busck).

This little Tineid larva works in the buds during July and August. The pupal stage lasts about three or four weeks, one adult having emerged on September 8.

A small, legless beetle larva nearly one-quarter inch long is also present in the buds, but have been unable to rear it. *Acanthoscelis acephalus* Say, which may be the parent form, was found on the plants early in the summer. It is, however, recorded as breeding in the pods.

The Evening Primrose Leaf Worm (*Phalonia oenotherana*, Riley).

On July 12, 1916, a small, greenish larva nearly one-half inch long was observed in the terminal leaves. The larva built a grayish silken cocoon in the breeding jar, the adult moth having emerged on July 24. The wings are yellowish while the terminal portion is reddish. The species was not common here.

MILKWEED (*Asclepias syriaca* L.) Insects.

The Milkweed Snout Beetle (*Rhyssematus lineaticollis* Say).

This species is recorded as breeding in the pods of milkweed, but I have not observed them doing so here. However, they were found breeding in the stems here. The adults were observed on the plants on June 29, making long, ugly, conspicuous gashes in the stem where they were ovipositing. Two or three cuts were made on each stem, inside of which three or four eggs were found beneath each cut. August 30, the larva entered the soil to pupate, but I did not succeed in rearing the adult.

Egg.—Length 1 mm.; 3/5 mm. wide. Color, greenish-white. Cylindrical and rounded at both ends.

Plutella maculipennis Curtis.

On July 27, three pupae of this little moth were found, enclosed in very light silken cocoons, conspicuously situated on the terminal leaves. One adult emerged August 7. This species is known as the cabbage plutella, and is listed by Sanderson as a minor pest wherever cabbage is grown.

The Monarch or Milkweed Butterfly (*Anosia plexippus*, Linn).

The larva of this common moth is present on different species of milkweed during the summer. It is greenish yellow, broadly banded with black. A pair of long, fleshy filaments are present on the second thoracic segment, as well as on the seventh abdominal segment. The chrysalis is about one inch in length, stout, and bright green, dotted with gold. Both the conical egg and the chrysalis may be found on the under side of the leaves. The adult is well known by all, being one of the migratory forms. An excellent account of the transformations of this insect is given by Riley, (Mo. 3rd Report p. 143).

"Lazily flying
Over the flower-decked prairies, west;
Basking in sunshine till daylight is dying,
And resting all night on Asclepie's breast;
Joyously dancing,
Merrily prancing,
Chasing his lady love high in the air,
Fluttering gaily,
Frolicking daily,
Free from anxiety, sorrow or care!"

The Red Milkweed Beetle (*Tetraopes tetra opthalmus*, Forst).

This long-horned, bright red beetle is common on milkweed from June to August. The larvae are said to bore in the roots and lower part of the stem, but as yet have not been located.

GROUND CHERRY (*Physalis* Sp.) Insects.

The Three-Lined Leaf Beetle (*Lema trilineata*, Oliv.).

This species is at times a pest of the potato and is related to the Colorado potato beetle. The beetles were found on the ground cherry during June, ovipositing their brownish yellow eggs on the under surface of the leaves. One larva pupated on July 8,

and the adult emerged July 27. The larvae are peculiar in that they carry their excrement on the back of their abdomen. There are probably two broods. The adult is about 3 inches long, of a yellowish color, head and thorax red, and three black stripes on the elytra.

MULLEIN *(Verbascum thapsus* L.) Insects.

The Mullein Weevil *(Gymnetron tetrum* Fab.*)*.

This species can be found swarming on the plant during the summer. On August 11, the larvae were nearly full grown in the seed pods. The adult beetles are black, robust and measure about 3 mm. in length.

GOLDEN ROD *(Solidago canadensis* L.*)* Insects.

The Goldenrod Leaf Beetle *(Trirhabda canadensis,* Kirby*)*.

These steel-blue larvae occur very abundantly on this plant during June. Pupation took place July 4, about one-half inch below the soil in the breeding cage. On July 13, adults emerged.

Larva—Length, about 10.5 mm. General color, steel-blue, with ventral surface lighter. Head black.

The Goldenrod Leaf Miner *(Agromyza positicata* Mg.)

The tips of the leaves are blackened by this little dipterous leaf-miner. On June 23, larvae pupated and on July 16, an adult emerged. Others collected on June 29, emerged on July 23.

Larva.—Length, about 4 mm. The two mouth-hooks are black, in front of which is a black, T-shaped structure. The horizontal portion of the T is curved. The spiracles are situated on rather long projections.

Gnorimoschema artimisiella Kear.

The larva of this little moth was also found mining in the tips of the leaves of the golden rod, on June 29, making an elongated blotch mine. One adult emerged on July 30. This species was also reared from *Artimesia abrotanum*, not, however, as a leaf miner, but as a web-worm.

(Boltonia asteroides (L) L'Her*) Anthonomus* Sp.

Seeds of this plant were also collected by Mr. Oswald and contained both larvae and adult weevils.

CUP PLANT (*Silphium perfoliatum* L.) Insects.

The Cup Plant Leaf-Miner (*Microrhopala vittata*, Fabr.).

The large leaves of this plant when infested look very conspicuous, owing to the large blotch mine of this beetle. As many as twenty larvae were counted in a single leaf. They became full grown July 17, while the adults emerged July 29. The pupae are motile, for they were observed to move around in the breeding cage. The adults measure about ¼ inch long, have an orange-colored thorax and an orange-colored stripe on each elytra.

ROUGH OX-EYE (*Heliopsis scabra* Dunal) Insects.

The Rough Ox-Eye Seed Maggot (*Agromyza virens*, Loew.).

The heads of this weed are often full of small dipterous larvae and puparia, together with small Tineid larvae. The adult form of the latter was not reared. The larvae of *A. virens* were numerous on July 20, in the flowers, mining all through the bases of the plants, there being fifteen or twenty in each head. On July 26, adult flies were emerging. This species seems to have variable habits, for it has also been reared from the lower part of the stem of the roadside thistle. (See Molloch.)

WILD SUNFLOWER (*Helianthus hirsutus* Raf.) Insects.

The Sunflower Tortoise Beetle (*Physonota unipunctata*, Say).

The species is reported as occurring on flowers of Crataegus, on the horse mint (Monarda) and the rosin-weed (Silphium), both larvae and adults feeding on the latter.

Life history.—The beetles and their egg-masses were first observed on May 29 eating the leaves of the sunflower. The eggs, which are laid in masses on the under side, hatch in about two weeks. Upon emerging, the young gather in clusters on the under side of the leaf and eat the epidermis. When abundant, as they sometimes are, they may destroy all the leaves on a single plant. Upon reaching maturity, they become more solitary and may be found on the upper side of the leaf. The larva carry their excrement on their caudal fork and are hence known as peddlers. On July 29 some had pupated, while on August 7 adults emerged, thus requiring about two months to complete their life history. There is one generation a year and the winter is passed in the adult stage.

Adult.—Immediately upon emerging, the thorax is creamy white, with the five black spots very distinct, the anterior ones being

the larger and closer together. The wing covers are dark brown and are covered with numerous conspicuous white spots, two of which are large and situated above the middle of the elytra. On the under side, most of the head and thorax is white, while the abdomen is crossed with white transverse bands.

Pupa.—Whitish; thorax with two small, longitudinal black lines near the middle and two larger horizontal lines on the lateral margins; abdomen crossed with black lines and with two curved lines on the upper lateral corners; four spines on each side of caudal fork; tips of caudal fork and spines black; ventral edge of thorax margined with black.

Larva.—Length, 13-16 mm.; width of head end, 5 mm.; length of caudal fork, about 4 mm., elongate; head end broad and rounded, tapering to caudal fork. Prothorax, mid-dorsum and parts of abdomen light yellow; rest of body brownish or black. The thorax is provided with four yellowish spines on each side, the tips and proximal portions of which are dark, while the anterior spines are smaller and almost wholly dark; abdomen with six small black spines on each side; head brownish; labrum and distal portions of legs black.

Egg.—Egg mass circular or elliptical and 6 mm. in diameter. Each egg 1.6 x 1 mm. When first deposited the egg mass is greenish-white, but later turns brownish.

Oviposition.—The female first carefully examines the underside of the leaves for about 5 minutes and when the right spot has been found, she does not change her position until all of the eggs are laid. The tip of the abdomen is then moved back and forth over a circular area, depositing a sticky substance. After this operation, the eggs are laid upon the sticky material, during which the abdomen is moved at uniform rate back and forth. Each egg is glued on and deposited separately as follows: A bit of sticky material is placed at one end of the circular area, and a thread is spun forth as the abdomen moves to the opposite side. Each egg is therefore held in place by a sticky thread attached to each end of it. After the surface has been covered with eggs, another layer is begun on top of the first and completed in like manner until a convex mass is formed, when the full number, about 30 or 40, have been laid. Threads are spun over them in both directions and then heavily glued over, especially near the edges. Oviposition may last 60 or 70 minutes. Upon hatching, the young larvae increase to about 1.7 mm. long, are light yellowish, while the head, thoracic shield, legs, and anal fork are black.

Natural Enemies.—Several egg parasites were reared on June 24. Mr. Girault of the United States National Museum identified the parasite as a new species of the superfamily Chalcidoidea. He named it *Aprostectus whitmani.*

The Sunflower Stem-borrer *(Straussia longipennis,* Wd.).

Life History.—The adult flies were first observed on June 1, while on June 3 they were ovipositing. The eggs are laid in the stem, one or two inches from the top of the plant. Upon hatching, the larvae travel down the pith of the stem so that in late summer, they are found mining in the pith at the base of the stem or in the roots. Full-grown larvae were found the last week in August. When the larvae reach the roots, the plant may begin to topple over. There is but one generation a year and the winter is passed in the pupal stage within the stems.

Egg.—1 mm. x 0.3 mm.; greenish-white; elongate; posterior end tapers somewhat more than anterior end, which is provided with a very small, transparent pedicel. Egg smooth all over.

Oviposition.—Oviposition habits are essentially as recorded by Lintner, who gives the only record of its food plant. When about to oviposit, the female runs up and down the top of the stem, with wings expanded. She then bends her body and inserts her long ovipositor in the stem one or two inches from the top, for about 15 or 30 seconds. Egg punctures appear as small, elongated, discolored areas, and if the stem is cut open at one of these points, the egg will be found lying obliquely in the middle of the stem and very conspicuous.

Larva.—Length, 8 mm. x 2 mm. wide; elongate, greenish-yellow. Two great hooks. The anterior spiracles are funnel-shaped, composed of a double row of about 14 lobes, each of which in turn appear under high power to end in a semi-circular chitinous area. The stigmal plates are about their diameter apart, each composed of three straight, elongate slits. These are arranged less radially than in other Trypetidae, the two upper ones being parallel, while the lower one is directed towards the middle one, is closer to it, and extends farther towards the center. The anal tubercles are small, somewhat truncate and situated below the stigmal plates at a distance less than the width of one of them.

The Sunflower Leaf-Rolier *(Trichotaphe inserrata*, Wal.).

This wary, active caterpillar was observed to roll the terminal leaves together in a conspicuous manner on June 29. It eats large holes in the leaf or sometimes rolls a part of the leaf over, feeding from the edges. Adult moths emerged on June 28 and July 3.

Pupa.—Length, 7 mm. by 2 mm. wide. General color, black. The dorsum of the posterior border of the first three abdominal segments with a band of golden hairs divided on the middle line; the first smaller, the third band measuring about 1 mm. wide. Just back of each band is a narrower, sparer band of similar hairs, bordered posteriorly by an orange-colored band. The 4th, 5th and 6th abdominal segments with a brownish band on their posterior border. The last abdominal segment clothed with numerous long hairs on the dorsum and at the tip. Head is also sparsely clothed with long hairs.

Larva.—Length, about 10.5 mm. Head and shield black; first two thoracic segments mostly brownish. Two lateral and one dorsal stripes present, beginning on the second segment. Legs dark on the outer side. Hooks of prolegs arranged in two rows with about 8 hooks in each row.

WHITE SAGE *(Artemisia ludoviciana* Nutt.) Insects.

The Wormwood Leaf Tyer *(Eucosma (Thiodia) artimisiana* Wals.)

The terminal leaves were commonly found tied on May 30 by a whitish caterpillar. Pupation took place June 30, while one adult emerged August 6. In the breeding cage, the larvae spun their silken cocoons on the stem near the base of the plant.

Larva.—Length, about 11 mm. General color, dirty white, somewhat darker above. Head yellowish. Legs darker on outer surface. On the center of the dorsum is a narrow pale band on each side of which is a broader one. The spiracles are conspicuously black. Prolegs with twenty hooks arranged in circle.

THE SOUTHERNWOOD *(Artimisia abrotanum* L.) Insects.

The Wormwood Web Worm *(Gnorimoschema artimisiella* Kearf.).

These small Tineid larvae make conspicuous webs among the terminal leaves and lateral shoots during the latter part of June. The grayish moths emerged on July 24, the pupal stage being about three weeks.

Larva.—Length, about 9 mm. The hooks of the prolegs number about eighteen, arranged in a circle, with small and large ones alternating.

This species was also reared as a leaf miner in *Solidago canadensis.*

BURDOCK *(Arctium lappa* L.) Insects.

The Burdock Seed Caterpillar *(Metzneria lappella,* Linn).

This caterpillar is very common in the seeds of burdock wherever found. The larvae are stout and the legs are so short that they appear lacking, giving the larva very much the appearance of that of the weevil type. For this reason, I was at first continually surprised to get only moths from the seeds. For some reason or other, perhaps lack of moisture, some of the over-wintering larvae did not transform, even until late the following fall, although they were alive all of the time. On June 23, pupae were still present in the seeds. The larvae consume the seeds, eating their way from one seed to the other.

ROADSIDE THISTLE *(Cirsium discolor* (Muhl.) Spreng.) Insects.

The Roadside Thistle Miner *(Agromyza virens,* Loew).

This species is also said to mine in the roots of clover. Lafayette, Indiana (F. M. Webster) and in the stems of *Ambrosia artemisiifolia.* L. Annals Ent. Soc. Amer. VI:321.

Life History.—On June 4, the insect was still in the pupal stage. Full-grown larvae were found August 24 mining in the stem about level with the ground and for a short distance above the ground. Altho as many as 15 or 20 may be present in a single stem, the plant appears perfectly healthy. There is apparently one generation a year and the winter is passed in the pupal stage. The egg and the method of oviposition has not yet been observed.

Larva.—Length, 5 mm. x 1.2 mm. wide. Elongate, cream-white in color, except for the mouth-hooks and anal plates, which are black. Nearly uniform in diameter, except at the ends. Two great hooks, one of which appears situated above the other. The anterior spiracles are located near the mid-dorsal line and end in about 6 or 7 lobes. Two very minute tubercles situated beneath each anal plate. The stigmal plates are elliptical and about their shorter diameter apart, each plate ending in about 15 or 16 pores. A stout black hook projects dorsally from each plate.

The Roadside Thistle Plume Moth *(Platyptilia carduidactyla,* Riley.)

The terminal shoot of this weed is often blackened and filled with excrement due to the work of the larvae of this moth. Larvae together with pupae were commonly found on June 26, while on July 6 one adult emerged. This species appears to be double-brooded, for during August the larvae were found working at the base of the flower heads from which one adult emerged September 8. The species is listed by C. V. Riley (Mo. 1st Report, p. 180).

Muscina stabulans, Fallen.

One June 26, dipterous larvae were observed feeding in the terminal shoot, together with larvae of the above species. On July 17, adults emerged and proved to be *Muscina stabulans.* In the breeding jars, the larvae were fed fresh leaves of the thistle upon which they fed and matured.

I have been unable to rear either the Anthomyid leaf miner or the weevil larva working in the upper roots. *Centrinus* sp. was observed on the plant on June 20, and may be the adult of the larvae in the roots.

The Painted Lady *(Vanessa cardui,* Linn*).*

This beautiful butterfly has the reputation of being the most widely distributed butterfly in the world, being found in all temperate regions. The hairy caterpillars make nests by rolling the edges of the leaves. They were found in June, some having pupated on July 12. One adult emerged July 25. The larvae measure about 1½ inches in length, are reddish brown or black with white and yellow dots. The head is dark brown or black and thickly covered with whitish hairs. The species was also reared from *Carduus* sp. mallow, and pigweed. It is also recorded as breeding on sunflower, beans, burdock, nettle, and various other thistles. A detailed description of this genus of butterflies is given by Essig (Jour. of Ent. & Zool. Sept., 1916).

CANADA THISTLE *(Cirsium arvense* (L.) Scop.) Insects.

The Thistle Seed Maggott *(Trypeta ruficauda,* Fabr.*).*

This species is reported as having been bred from thistle heads at Ottawa, Canada, by Mr. E. P. Felt (Felt, 29th Report, p. 171—1915).

Life History.—The flies have as yet not been observed in the field. Full-grown maggots were found within the heads and destroying the seeds on August 11 and thereafter. The larvae probably enter the soil and pass the winter as pupae.

Larva.—Length, 4.5 mm. x 2 mm. wide. Color, creamy white except the hind end, which is very dark brown. Two great hooks. Body stout, tapering in front; surface of body covered with minute, acute granules; fusiform areas indistinct. Anterior spiracles funnel-shaped and ending in 7 or 8 lobes. Anal tubercles apparently lacking. Two minute circular areas below the stigmal plates. Stigmal plates lighter in color; not noticeably elevated, about their diameter apart; each composed of three straight slits, radially arranged. The slits are wider at the outer end and notched.

The Canada Thistle Midge *(Dasyneura gibsoni,* Felt.).

In 1911, Gibson, of Canada, reared a new midge from reddish larvae found in the flower heads. These larvae are also present in Minnesota and are apparently the same species. In some parts of Indiana the Canada thistle is reported to have been completely destroyed by this little midge.

PRICKLEY LETTUCE *(Lactuca scariola* L.) Insects.

Phalonia buntcana, Robinson.

The heads of this weed are often infested with small Tineid larvae. Pupae were also present on August 14, one adult having emerged on August 20. The adult moth is a little over ¼ inch long with the fore part of the wing grayish white, while the terminal portion is brownish red with a darker brown transverse band.

Phorbia Sp.

Although I did not succeed in rearing this fly, the adults were present on the plant. The larvae are common in the heads, feeding on the seeds.

SUMMARY OF INFORMATION ON THE INSECTS ATTACKING WEEDS IN MINNESOTA

Common Name of Weed	Name of Weeds	Name of Insect	Part of Plant Attacked
Curled dock	*Rumex crispis*	*Pegomyia bicolor*	Leaf miner
Curled dock	*Rumex crispis*	*Mantura floridana*	Leaf miner
Wild Buckwheat	*Polygonum convolvulus*	*Gastroidea polygoni*	Leaf feeder
Lambs quarters	*Chenopodium album*	*Pegomyia hyoscyami*	Leaf miner
Lambs quarters	*Chenopodium album*	*Gnorimoschema artimisiella*	Leaf tyer
Purslane	*Portulaca oleracea*	*Aprosthena zabriskei*	Leaf miner
Partridge pea	*Cassia chamaecrista*	*Bruchus cruentatus*	Seed pods
Prairie clover	*Petalostemum purpureum*	*Apion varicorne*	Flowers
Milk Vetch	*Astragalus canadensis*	*Bruchus schrankiael*	Seed pods
Milk Vetch	*Astragalus canadensis*	*Tychius arator*	Seed pods
Milk Vetch	*Astragalus canadensis*	*Phycid sp.*	Leaf tyer
Milk Vetch	*Astragalus canadensis*	*Phorbia sp.*	Seed pods
Evening Primrose	*Oenothera biennis*	*Tyloderma foveolata*	Stem miner
Evening Primrose	*Oenothera biennis*	*Mompha stellela*	Buds
Evening Primrose	*Oenothera biennis*	*Phalonia oenotherana*	Leaf feeder
Milkweed	*Asclepia syriaca*	*Rhyssematus lineaticollis*	Stem miner
Milkweed	*Asclepia syriaca*	*Plutella maculipennis*	Leaf feeder
Milkweed	*Asclepia syriaca*	*Anosia plexippus*	Leaf feeder
Milkweed	*Asclepia syriaca*	*Tetraopes tetraopthalmus*	Root borer
Ground cherry	*Physalis sp.*	*Lema trilineata*	Leaf feeder
Mullein	*Verbascum thapsus*	*Gymnetron tetrum*	Seed pods
Goldenrod	*Solidago canadensis*	*Trirhabda canadensis*	Leaf feeder
Goldenrod	*Solidago canadensis*	*Agromyza posticata*	Leaf miner
Goldenrod	*Solidago canadensis*	*Gnorimoschema artimisiella*	Leaf miner
Goldenrod	*Boltonia asteroides*	*Anthonomus sp.*	Seeds
Cup plant	*Silphium perfoliatum*	*Microhopala vittata*	Leaf miner
Rough ox-eye	*Heliopsis scabra*	*Agromyza virens*	Flower heads
Sunflower	*Helianthus hirsutus*	*Physonota unipunctata*	Leaf feeder
Sunflower	*Helianthus hirsutus*	*Straussia longipennis*	Stem miner
Sunflower	*Helianthus hirsutus*	*Tricholaphe inserrata*	Leaf roller
White Sage	*Artemisia ludoviciana*	*Eucosma(Thiodia)Artimisiana*	Leaf tyer
Southernwood	*Artemisia abrotanum*	*Gnorimoschema artimisiella*	Leaf tyer
Burdock	*Arctium lappa*	*Metzneria lappella*	Seeds
Roadside thistle	*Cirsium discolor*	*Agromyza virens*	Stem miner
Roadside thistle	*Cirsium discolor*	*Platyptilia carduidactyla*	Leaves and Flower heads
Roadside thistle	*Cirsium discolor*	*Muscina stabulans*	Leaf feeder
Roadside thistle	*Cirsium discolor*	*Vanessa cardui*	Leaf tyer
Canada thistle	*Cirsium arvense*	*Trypeta ruficauda*	Seeds
Canada thistle	*Cirsium arvense*	*Dasyneura gibsoni*	Seeds
Prickley lettuce	*Lactuca scariola*	*Phalonia hunteana*	Flower heads
Prickley lettuce	*Lactuca scariola*	*Phorbia sp.*	Flower heads

MINNESOTA BILL BUGS

O. G. BABCOCK.

In the year 1899, Lugger reported several species of bill-bugs in Minnesota, especially in the vicinity of the lake shores. During certain seasons, they were reported to be remarkably numerous, **Sphenophorus ochreus** (Lec.) and **S. costipennis,** Horn, being the most common species. In 1913, an observer near Savage, Minnesota, informed us that he distinctly remembered seeing holes in the corn leaves as long ago as 1898 and similar injury in 1903.

Our records show that in 1910, Spooner, while investigating a field of corn which had been under cultivation for forty years, found bill-bugs at work in hills of young corn at Shakopee, Minnesota. This field had been flooded in 1903 and partly covered by high water several seasons since. In the late spring of 1912, 25 acres of corn on this same farm was practically destroyed by *S. venatus.*

Distribution.

In addition to *S. costipennis* and *S. ochreus, S. venatus* is known to occur along the Minnesota River from Shakopee to the Mississippi. In the Fourteenth Annual Report of the State Entomologist for 1911-12 is found a note upon *S. ochreus* by Somes, who states that he found it feeding upon the heads of velvet chaff wheat while in the milk. The blue stem, a smooth or beardless variety that was plowed in the spring, was very slightly affected, the velvet chaff being fall plowed. Somes reports it in that year as being quite abundant in the southern part of the state. Upon rare occasions this species is known to attack corn. *S. zeae* also occurs along the Minnesota River from Shakopee to the Mississippi and thence to Lake City. We have also found it three to four miles back from the river on high land at Owatonna. Here it was infesting a local patch of sedge *(Cyperus esculentus)* in a low spot about twenty feet in diameter.

LIFE HISTORIES.

Sphenophorus venatus.

On June 5, 1912, an investigation of this pest was made at Shakopee. One farmer lost fully twenty-four acres of field corn.

On this date, the adults were seriously attacking the young corn which was, on an average, one and one-half to two feet high.

Only a crumpled, wounded stalk here and there succeeded in making any growth to speak of. About one acre, which was higher than the rest, in one corner of the field was found not to be infested.

From observations, it appears that the emergence of the adults in the spring is controlled by both temperature and moisture conditions. On June 9, 1911, they were found feeding upon young corn, just out of the ground, while on June 5, 1912, the beetles had already accomplished their work of destruction of the second planting. On May 29, 1913, much of the corn was from one to three inches high. The adult beetles were very few and very hard to find. Some of the corn showed old feeding punctures which would place the appearance of the adults at about May 27.

Many instances were found where the adults were feeding upon exposed, unsprouted corn and partly buried, sprouted corn. So far as observed, only the starchy portion was eaten. In one instance, five beetles were found feeding upon a single kernel that was buried three inches below the surface. During May and early June it was noticed that they traveled on foot. Not a single instance of flight was observed by the writer. No copulating was observed in the early season but, beginning in the fore part of June, mating was observed, and was at its height in July.

From a lot of adults collected on May 29th, it was found that their average life period from time of emergence in the spring until death is approximately fifty-eight days.

Observations showed that not every hill was infested except in severe years, but when infested, from one to three adults were found to a hill. The largest number found was thirteen. On July 5, 1912, after a rainstorm, twenty adults were found feeding upon one ear of corn that was partially buried in the soil, and forty-three upon another similar ear. When feeding upon the corn plant, they generally fastened themselves, head downward, from the level of the soil to one and one-half inches above the soil, on the shady portion of the plant. The head is kept moving a little from side to side and backward and forward, until a deep slit is made, one or more slits often resulting in the death of the corn plant. Whenever the sun shone hot and the soil was beginning to dry, the bill bugs would bury themselves from a depth of just below the level of the soil to one and one-half inches deep. Travel would also cease on very dry days. When clinging to the stalk and disturbed, they readily feign death and are usually quite hard to pull off, especially if disturbed while feeding.

Egg Stage.

About the middle of June, egg-laying begins and lasts until the latter part of August. From all observations made, eggs of *S. venatus* are never deposited in stalks of corn, not even under artificial conditions where corn only was supplied. It was not until August that eggs were actually found in the field, although eggs were obtained in the insectary as early as June 16. The eggs were always laid lengthwise, inside of and generally beneath a sheath of *Cyperus esculentus* and were found to be from two inches below the soil surface to three inches above the level of the soil. The majority of the eggs, however, were deposited about one inch above the surface of the soil. The actual act of placing an egg has not been observed, but after it is deposited, it is found to be between the two surfaces of a leaf sheath. Most of the eggs were held between two parallel vascular bundles, enough of the softer material being eaten away on each side to allow the egg to fit into place. In a few cases, one or both of these strands or vascular bundles were broken; however, the eggs seemed to remain in place. Oftentimes, one to three eggs were found in a single stem. The presence of the eggs is indicated by a dark brownish stain at the point of the injury on the sheath, this stain often being noticeable on two to three sheaths on each side of the puncture.

Eggs were obtained in the insectary on the following dates: June 16, 23, 24, 27, 29, and July 1 and 8. The incubation period was determined to be 3, 4, 5, 10, 12, 14, 15, 17, 19, 20, 21, 22, and 34 days, respectively, or an average of 17.18 days.

Larval Stage.

When the larva is first hatched, the head as well as the body is somewhat translucent in color, but after a couple of hours, the head begins to turn brown. The first larval stage is somewhat convex dorsally, especially anteriorly, head brownish, mandibles dark brown, folds of trunk intricate and hairs scarce; four long anal hairs, very distinctive, but difficult to see.

The larva does not burrow up the stem more than three or four times its own length. In no case have I ever found a single larva inside of or feeding upon the bulbous roots of *Cyperus esculentus*, although in the insectary they were fed upon the bulbs exclusively. The exact number of molts is not known; however, it

is certain that two molts occur as their cast skins were found—the second casting being found when the larva was about one-quarter inch in length.

In the field, the larval period was found to last from June 29 to August 20, and very probably extends well into September; however, the life of an individual larva is much less. The occurrence of larvae and pupae as late as October 9 is no doubt due to the long egg-laying period. Following this and other observations, the probabilities are that this species passes the winter as a pupa or larva, inside of the pupa cell.

On the inside of and near the base of the plant, the larva, when fully grown, makes for itself a somewhat elliptical cell out of the borings. This cell is rounded at either end and almost parallel on the sides. Inside of this, the larva pupates. Some time before changing to the adult stage, the pupa gradually changes to a dark brown and remains so even after the adult stage is reached, but later the color turns much darker. Occasionally some of the brown color will remain, even after emergence into the open. From the above information, it is quite evident that *S. venatus* has but one generation a year in this state.

Sphenophorus zeae.

On June, 1913, *S. zeae* was found contemporary with *S. venatus* in all of its habits, at Savage, Minnesota. The owner of the piece of land where most of the observations were made informed me that he distinctly remembers seeing holes in the corn leaves in 1903 and that he believes he observed similar injury in 1898.

Adjoining an area of sedge was a field of corn that was very badly infested with *S. venatus* and *S. zeae*. To the north was a strip of last year's corn left unplowed, while the other half of the field was plowed and seeded to potatoes. Volunteer specimens of the yellow nutgrass, *Cyperus esculentus*, was found throughout the potato field in spite of thorough cultivation. The rows of corn next to the hayfield contained a good deal of the yellow nutgrass which gradually became less as the distance increased.

On August 20, another visit showed the presence of the eggs and larvae of *S. zeae* in abundance in much of the volunteer sedge in both the cornfield to the west and the potato field to the north. Many empty pupa cells were found, thus indicating that many adults had emerged.

As late as October 9, a few larvae and pupae were found in the field, as well as many empty pupa cells. All larvae brought in

pupated on the following day. They must therefore pass the winter as pupae or adults, or both, within the pupa cell. Two parasitic cocoons were found, one of which was inside a cell of *S. zeae*, judging from the remains of the larvae in the cell. The other cocoon was apparently in a cell of *S. venatus*.

So far as observations go, the native food plant of *S. zeae* is the same as that for *S. venatus*. The adult beetles will leave the native food for the corn when it is near by, and feed upon it with the same relish and the same habits as *S. venatus*. No eggs of *S. zeae* were found in corn.

The larvae have not been found in corn, but like *S. venatus*, spend their lives at the base of and in the central region of the yellow nutgrass, the burrow not being longer than three or four times the length of a larva. In this burrow, it makes for itself a similar but larger elliptical cell of the burrowings and pupates therein.

The beetles travel on foot, although the power of resistance to drowning is very great. Twenty-four adults of *S. venatus* were completely submerged in water for different periods of time, up to seventeen hours and were found to suffer no harm. From this, it may be inferred that if high water occurs at the proper time, it is quite possible for many adults to be carried long distances and infest a new field of sedge farther down the river.

Food Plants.

Practically all of the Sphenophori feed naturally upon some one or more species of Scripus although other plants are often attacked. Such is the case with *S. venatus* and *S. zeae*. Both species pass their entire life history in association with the yellow nut grass, but when sprouting corn, wheat or timothy is near by, it is very likely to be attacked and, in fact, the adults prefer the corn to the native food. Leaves of *Cyperus esculentus* containing holes in rows were very similar to those of corn. Generally speaking, grass crops that are not too far from Scripus are subject to attack. Under artificial conditions, it was found that the adult beetles will feed upon several other plants as, for example, *S. venatus* will feed upon potato leaf and stem, leaves and stem of fox-tail or wild barley, crown and flower of dandelion, timothy, oats, wheat, corn, and yellow nutgrass, but showing preferences for yellow nutgrass, corn, wheat, oats, and timothy. Pepper grass, sweet clover, wild lettuce, milkweed, horseweed, ragweed, hayweed

(Ambrosia sp.), cabbage, lettuce and bean were not touched. *S. zeae* will at least refuse mammoth red clover; alsace clover, and ragweed.

Methods of Control—(Mainly for S. venatus).

Except in rare instances, attacks from billbugs are confined exclusively to river-bottoms and lake shore lands when a field of corn and possibly wheat, oats or timothy is planted beside a field of the yellow nutgrass or where all or a portion of the yellow nutgrass is "turned over."

In Illinois, where *S. parvulus* exists, timothy appears to be a very dangerous crop to plant, but so far as observed, *S. venatus* and *S. zeae* do very little if any damage.

Fall and spring plowing does not appear to control either species for two reasons; first, from a practical point of view it would be next to impossible to destroy all of the sedge, unless a very thorough method of summer fallowing was carried out. This would mean a year lost in time and money, especially so on river bottom land, which is subject to partial losses by high water; and second, from preliminary experiments where two adults of *S. venatus* were placed at the bottom of and inside of a two-inch glass tube with different heights of field placed on top of them. When two, three, and four inches of soil was placed on top of the beetles, they all reached the surface in three, four, and seven days, respectively. In another lot, where two, two and one-half, and three and one-half inches of wet, compact soil was used, the beetles reached the surface in approximately three to ten days. It was discovered that with this wet soil, they would come to the top and go back down again.

On July 10, 1913, when the experiment was again tried, four specimens of *S. venatus* were placed at the bottom of a tube one inch in diameter, having fourteen inches of damp but not wet field soil in it. On July 18, or eighteen days after, one adult reached the surface, but for two and one-half days this adult remained a half inch below the surface before coming to the top. On July 22 another adult reached the surface and on August 2 the third reached the top, but it was not until August 3 that the last billbug made its escape, in a total period of twenty-four days. To be conclusive, similar experiments should be tried under field conditions; however, the hint given is that late spring plowing might prolong the period of emergence, provided the adults hibernate near or on the surface; otherwise spring plowing would probably be a detriment.

From a study of the life-cycle, it will be seen that the best time to plant corn is at least ten days (15 is better) after the adults make their appearance in the spring. The greatest amount of damage is done before the mating season.

Another significant fact is that there are years of abundance and years of comparatively few billbugs, the former following a year of high water. Just what part parasites play in this role is still a question.

Two other methods of control suggest themselves; crop rotation and the use of poisons. Where practicable, drainage would no doubt be of considerable help, provided the extra expense would be compensated for.

Crop Rotation.

Rotating corn with potatoes, timothy, or wheat, to be again followed by corn, does not rid the field of billbugs. If rotation is followed, fall plowing, followed by the disk-harrow or harrow, is advised; again harrow or disk in the spring, if a new field of *Cyperus esculentus* was broken in the fall. Sow the field to a root crop, such as beets, or seed to onions or cabbage. This will demand very thorough cultivation, thus keeping down volunteer nutgrass. Manure in late summer or early fall and seed to clover, or manure and fall-plow, seeding to corn the following spring, this to be followed by a legume.

Other combinations may be worked out according to controlling local conditions as:

First Year—Onions, beets or cabbage. Early cabbage may be followed by certain varieties of beans or peas. Field to be manured and plowed in the fall.

Second Year—Corn, timothy, wheat, or potatoes.

Third Year—Seed to clover or some other leguminous crop.

While the above may not be an ideal crop rotation for bottom land, yet the yellow nutgrass must be completely killed out or the land summer fallowed.

Poisoning.

Since the adults are very greedy when they first make their appearance in the spring and are known to be very fond of ear corn, it is quite probable and even possible that broken bits of ear corn could be soaked in water containing sweetened arsenicals and then scattered about over the field. The objection to this method would be the possible killing of birds; however, the evidence of birds being killed by arsenical spray methods is negative.

FURTHER OBSERVATIONS ON MINNESOTA BIRDS; THEIR ECONOMIC RELATIONS TO THE AGRICULTURIST.*

F. L. WASHBURN.

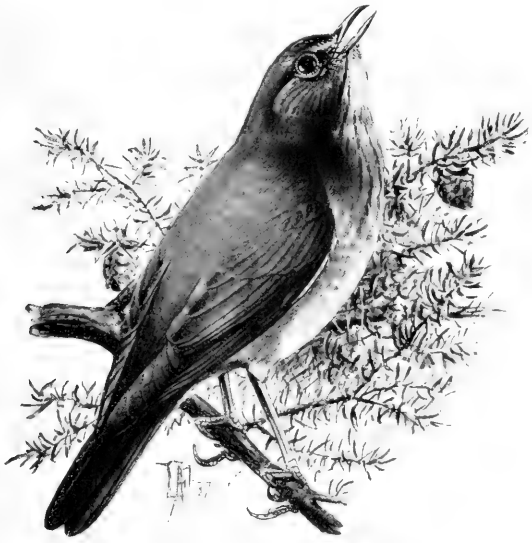
The increasing interest in our birds prompts the Entomologist to add to the information published with colored plates in Circular 32, from this office, by issuing the present leaflet. It is manifestly out of the question to discuss all of our bird residents and visitors, or even to list and figure them in a circular. It has been our aim, therefore, rather, to describe, briefly, different types representing certain groups common in Minnesota. There has been a great demand for Circular 32 on the part of schools and it is hoped that these brief accounts of Minnesota bird life may also be of service.

We are particularly fortunate, through the kindness of the artist, Louis Agassiz Fuertes, of Mabel Osgood Wright, the living author, and the Macmillan Company, publishers of "Citizen Bird," to be able to present here a few of the excellent and accurate illustrations with which that publication is adorned. It is with the greatest pleasure that we acknowledge our appreciation of the courtesy extended by the above.

*Also printed as Circular No. 35.

THE WOOD THRUSH AND WILSON THRUSH.

The distinct, sharply-outlined, large, round, black spots on the white breast and under parts of the Wood Thrush, together with



Wilson Thrush.

its larger size, will at once distinguish it from the following species—the Wilson Thrush or Veery, with which it vies in the matter of song. In the latter species, the white breast is more or less tinged with cream and dotted with small, somewhat indistinct brownish, wedge-shaped spots. Its upper parts are brownish but not as bright as in the Wood Thrush.

The first-named bird is 8¼ inches long; the latter (Veery) a little over 7 inches. Both lay greenish-blue eggs in a coarse nest modelled somewhat after the nest of the robin, but the nest of the Veery is on or close to the ground. The beautiful song of both of these birds, coming from the dense woods, if once heard, is never forgotten and they are both important insect-eaters; in fact, the entire thrush family, tho occasional members may be attracted to berries and fruit, notably in the case of the robin, must be credited with being benefactors of the farmer and fruit raiser. Forbes, after a somewhat exhaustive examination of their food habits, states that 61% of the food of thrushes consists of insects.

THE BROWN THRUSH OR BROWN THRASHER.

The excellent illustration here given is sufficient to enable us to recognize this very common bird of our thickets and fields. Rufus brown above, with black spots on a white ground below, its

colors and conspicuously long tail make it a notable object when it seeks a prominent position on a lofty branch, preparatory to singing. Its song, while striking, will not compare, we believe, with those of the two preceding nor with that of the cat bird. One of its chief charms, perhaps, lies in the fact that it is an accompaniment of the welcome spring weather. We have been so struck by the little rhyme credited to "Olive" in "Citizen Bird," which certainly is very descriptive of its habits and song, that we venture to repeat it here:

"My creamy breast is speckled
(Perhaps you'd call it freckled)
Black and brown.

"My pliant russet tail
Beats like a frantic flail,
Up and down.

"In the top branch of a tree
You may chance a glance at me,
When I sing.

"But I'm very, very shy,
When I silently float by,
On the wing.

"Whew there! Hi there! Such a clatter.
What's the matter—what's the matter?
Really, really?

"Digging, delving, raking, sowing,
Corn is sprouting, corn is growing.
Plant it, plant it!
Gather it, gather it!
Thresh it, thresh it!
Hide it, hide it, do!
(I see it—and you.)
Oh! I'm that famous scratcher,
H-a-r-p-o-r-h-y-n-c-h-u-s r-u-f-u-s—Thrasher
Cloaked in brown."

While the brown thrush may take a little fruit or grain, it is a good insect-eater and, as a ground feeder, scratching amongst fallen leaves, it picks up many injurious insects, and it must be admitted, some useful forms as well, the ground beetles, for example.

THE CAT BIRD.

The writer has been so forcibly reminded of the beautiful song of this bird by the extremely natural appearance of the drawing, that he is led to include it here as a plea for the bird, upon the ground of its qualities as a songster.

THE YELLOW-BELLIED WOODPECKER OR SAPSUCKER

This illustration will prove helpful in enabling one to distinguish between this injurious form and other woodpeckers which are useful. In striking contrast to other birds whose tongues are extensile for extracting borers from infested trees, the tongue of this species has a somewhat "brushlike" tip. It cannot be protruded to any extent, and is thus modified for an entirely different diet from that of other members of the same family. That it seriously injures birches, maples, mountain ash, apple, evergreen, and other trees by girdling them with holes in its seeking for sap and cambium goes without saying. It may and probably does consume a few insects which are attracted to the bleeding holes, but not in sufficient numbers or of the right kind to compensate for the injury inflicted upon the trees. The bird is about 8½ inches long. The adult male has crown and throat red, breast black, and belly a shade of yellow. The female has no red on throat and the red color of the crown is sometimes replaced by black. The downy wood-

pecker, which is one of our most useful birds, is under 7 inches in length and has a scarlet band on the back of the head in the male—not on the crown. On account of its small size and difference of coloration, it need not be confused with the species under discussion.

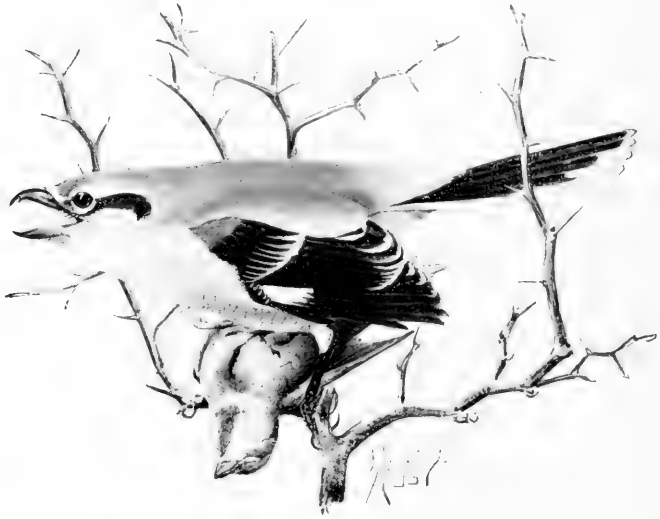
THE BELTED KINGFISHER.

The above virile picture gives an excellent idea of the appearance of this vivacious, noisy, and, it must be confessed, at times injurious bird. Naturally a lover of wood-bordered streams and ponds, its noisy rattle is a fit accompaniment to the sound of running water and it is here that it takes frequent toll of fish which might otherwise have lived to fill the angler's creel. Fish in ponds and streams, therefore, suffer as a result of its rapacious appetite, but its depredations become of marked importance when it habitually takes its food from ponds or streams of those who raise trout on a commercial scale. Frequently, the shot gun is used by the fish-breeder in self-defense; or taking advantage of the bird's habit of frequenting a perch over the water, whence it can see its prey below the surface, a steel trap is placed on the top of an upright pole planted in the pond and the marauder captured therein. Its white eggs are placed at the end of a long burrow in some bank near the water.

THE AMERICAN REDSTART.

Fuertes' fine drawing illustrates the male (1) and female (2) of this beautiful bird. One of a large group of wood-warblers, examples of which (Blackburnian, Maryland yellow-throat, Chestnut-sided, and Yellow-rumped) are shown in color. The male is striking, not only on account of his brilliant coloring, but also on account of his conspicuousness, since he is extremely active and this activity coupled with the above mentioned brilliancy of coloring, makes him an object to catch the eye of even an indifferent observer. As if conscious of his beauty (breast, head, and back a deep, lustrous black; long wing-feathers at base a rich salmon; about half of the outer tail feathers, sides of breast, and body beneath wings deep salmon) he is continually spreading and flirting his tail, extending his wings, and making short flights from the trees seeking insects, much after the manner of our common fly-catchers. The female is much duller-colored, greenish-gray on head and back and yellowish where the male is salmon.

THE GREAT NORTHERN SHRIKE; BUTCHER BIRD.



A misconception regarding this bird prevails among many, a mistake which is encouraged by its name and perhaps added to, unfortunately, by the illustrations frequently seen, showing the bird with a captured sparrow. It is true, however, that he kills sparrows and other small birds, a fact evidently fully appreciated by his intended victims, since a panic among them is caused by his appearance, but he atones for this by killing and devouring field mice, shrews, and injurious insects. It is to his credit, also, that he is a persistent enemy of the English sparrow—a bird responsible for many ills and now recognized as one means of dispersal of the much-dreaded San Jose scale. The great northern shrike is common in our fields until late fall, sometimes as late as December in the latitude of Minneapolis, and even later in the southern part of the state, and recognized by his peculiar flight, close to the ground, by his size and coloration. He is about 10¼ inches long, black, gray, and white. At times, he is something of a songster. Amongst injurious insects captured, we might mention grasshoppers and various caterpillars.

AMERICAN CROSSBILL.

A frequent visitor from the North in the fall and during the winter. More common in the timber and wooded country than in open sections, though occasionally seen on some high tree in the middle of a large city. Wherever observed in this latitude, they are always tame and easily approached. The writer has found them in July in the upper Red River Valley, feeding upon the insect contents of poplar galls. These were probably young birds and their occurrence here at that date would indicate the birds breeding at no very great distance.

THE BOBOLINK.

This dandy amongst birds—a favorite of bird lovers and subject of many a song and poem—is a common and welcome summer resident here, filling the fields with drunken melody, while his more modestly-colored mate is sitting quietly on her nest, well hidden in grass or clover. So familiar to all is this songster that with the above excellent illustration before us, no verbal description is necessary.

The beauty and song of the male bird are but transient qualities, for after the breeding season, he loses his fine clothes, becomes dull olive-colored, streaked with black, like the female and young, and, in the fall, flocks southward to wild rice marshes and cultivated rice fields, wintering in South America. At night one frequently realizes flocks of these birds are passing, by hearing their metallic "Chink" in the darkened sky above. As "reed bird" and "rice bird," they find their way into the markets of the East and South, fattened by voracious feeding in the rice fields. While with us in the North, they eat large numbers of injurious insects.

THE RED-WINGED BLACKBIRD.

However injurious the group of blackbirds become in late summer and fall, in the spring and early summer they almost or quite pay for their depredations by consuming large numbers of injurious insects. The Red-wing is a welcome arrival in the early spring. Its really melodious note at that time is tuneful comfort to bird lovers, after a long winter devoid of feathered singers. At that time, the position taken by the bird in uttering its characteristic note or notes discloses to advantage its scarlet shoulders well set off by glossy black of wings, body, and tail. The grayish-brown female, streaked with black, we may not notice, but the male compels attention.

The Department of Agriculture has made an exhaustive study of this bird's food habits and finds about 7/8 of its diet consists of harmful insects and weed seeds. Locally when in large flocks, as above intimated, it—with others of its tribe—may be very harmful and a resort, on the part of the farmer, to extreme measures is justified.

THE WHIPPOORWILL AND NIGHT HAWK.

These two birds, sometimes confused by the uninitiated, yet perfectly distinct species, are both insect-eaters and one of them—the Whippoorwill—not often seen and not very well known. It is a bird of the woods, unless disturbed, flying only by night, and characterized by its peculiar note, oft-repeated: "Whip-poor-will!" "Whip-poor-will!" "Whip-poor-will" with a "cluck" or "chuck" before each call, audible to one close at hand. This song, quite forceful and penetrating, is heard in the first part of the night and just before dawn. In coloration, the bird harmonizes closely with the wood colors. When flushed, it disappears with absolutely noiseless flight.

Night Hawk.

The Night Hawk, on the other hand, is markedly a bird of the open, frequently in flight in the afternoon and early in the evening, high in the air, uttering at frequent intervals his rather

harsh cry and occasionally, on half-closed wings, darting down to the earth with a booming sound, made, it is claimed, by the rush of air through his primary wing feathers. The two eggs of the Night Hawk are laid on the ground or in the fields, or even on a flat rock, with no semblance of a nest; occasionally, they are found on flat roofs of buildings in cities. The Whippoorwill's eggs, also two in number, are laid on the ground or on a log or stump in the woods, likewise protected by no nest. The coloring and markings of the two birds also serve to distinguish them. The Whippoorwill's colors partake of the browns, while the Night Hawk is grayish. The tail of the former has the three outer feathers white for about two-thirds their length. Further, the end of the tail is rounding. The latter-named bird has a conspicuous white patch on each wing; its tail is forked. The Whippoorwill feeds largely on moths and beetles; the Night Hawk on May flies, gnats, dragon flies, grasshoppers, etc.

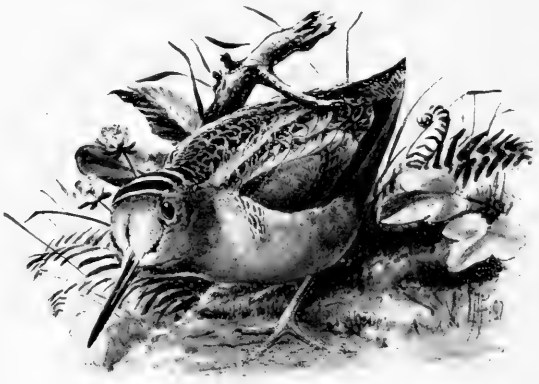
THE QUAIL.

Amongst our game birds, the Quail gets most of its grain after the crop has been gathered; it eats insects, some of them very injurious; large numbers of potato beetles and chinch bugs have

been found in its crop; army worms, cut worms and wire worms form a portion of its diet. It appears to be growing more abundant in the State from year to year, and working farther north each season, yet its occurrence in any latitude in any year naturally depends upon the severity of the preceding winter and upon general climatic conditions.

The Virginia Quail or Bob White is holding its own fairly well in Minnesota in spite of our severe winters, pushing its way farther north when conditions are favorable. This bird is such a good friend of the agriculturist that it deserves protection, although its fine qualities as a table bird make it an object of pursuit on the part of hunters. Potato bugs and even chinch bugs have been found in its crop and grasshoppers as well as many other varieties of injurious insects compose a large proportion of its bill of fare.

THE AMERICAN WOODCOCK.



A somewhat rare bird in Minnesota, frequenting the low, wooded, water-courses and generally resorting to the higher lands only during the night. This beautiful game bird is pre-eminently a night-flier and a night-feeder. Its large eyes, placed well toward the top of its head, are not only enabled to gain impressions from above, when the bird's soft beak is buried in the mud, but also are in a position to receive all available light. When flushed, the bird rises softly, directly upward until clear of the brush and then pauses an instant before starting away from the intruder. Their four buff-colored eggs spotted and blotched with brown, are laid on leaves on the ground in an excuse for a nest. This bird has no economic bearing upon agriculture. It is protected in Minnesota until 1918.

THE HERRING GULL AND COMMON TERN.

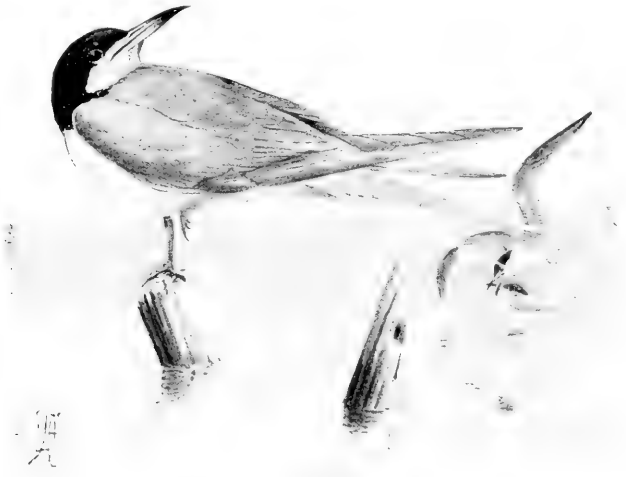
The gull family is a group beneficial to farmers living in a prairie country.

The Black Tern, found so abundantly about our prairie sloughs, and perhaps the most abundant representative of the group in Minnesota, is a good friend of the farmer, for when the sloughs are dry, and even before, they consume large numbers of grasshoppers. Amongst others of this family (gulls), Franklin's Rosy Gull is one of the chief breeders within the State's borders and is a voracious eater of grasshoppers, and, while no illustration of this bird is available, we are pleased to be able to present an excellent drawing of the Common Tern in this publication which will serve to illustrate the group.

The Herring Gull—a good scavenger upon the shore of lake or ocean, typifies the larger members of the family and the species itself, while not as abundant perhaps as other gulls which breed in some of our lakes—is, nevertheless, a Minnesota summer resident, arriving in the southern part of the state early in April, shortly after that working its way north, where some at least nest in our larger lakes, notably Lake Mille Lacs. I have observed them at Devils Lake, Otter Tail County, in October and also find the following observations amongst my notes taken some years ago: "At Lake Mille Lacs, after the wind has been blowing from the East a day or more, these gulls and the two following species, namely, L. *delewarensis* and L. *philadelphia*, are plenty along the west shore, flying up and down the beach and occasionally alighting to pick up small lacustrine mollusks washed ashore with the

weed matter. About two miles from the south shore of the lake lie three barren, rocky islands, which are frequented by the gulls in the breeding season. The larger of the three, called Stone Island,—or Spirit Island by the Indians,—containing about three-quarters of an acre and with its top about 20 feet above the surface of the water, affords on its rocky surface a nesting place for hundreds of gulls."

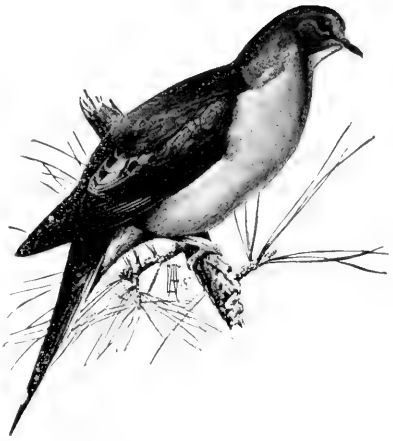
Stomachs of the Herring Gull are found to contain grasshoppers, fish, mollusks, and, in one instance, the remains of a marsh



The Common Tern.

hare, probably consumed as carrion. Professor Aughey reported finding in the stomachs of each of four Black Terns from 47 to 84 grasshoppers or locusts, and in two stomachs examined, from 28 to 59 other insects.

THE MOURNING DOVE.

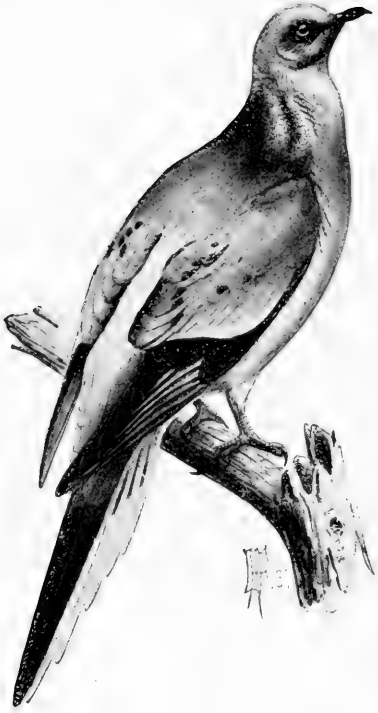


It is unfortunate that the Mourning Dove has been so long included amongst our game birds, as it deserves protection, and we are glad to note that by an act of the Minnesota Legislature at its 1915 session it was placed upon the constantly protected list. A bulletin from the United States Department of Agriculture (Farmers' Bulletin 513, Bureau of Biological Survey) reports the finding in one stomach of seventy-five hundred seeds of yellow wood sorrel; in another sixty-four hundred seeds of foxtail, and in a third twenty-six hundred seeds of slender pospalum, forty-eight hundred and twenty seeds of orange hawkweed, nine hundred fifty of hairy vervain, one hundred twenty of Carolina cranesbill, fifty of yellow wood sorrel, six hundred twenty of panic grass, and forty miscellaneous weed seeds.

The drawing is included here for comparison with that of the Passenger Pigeon or Wild Pigeon with which the species is sometimes confused.

THE WILD PIGEON.

A vanished bird. Several reports from various localities in Minnesota have reached the University of the occurrence of this beautiful bird so common years ago within the confines of the state, but these rumors appear to have arisen either from confusing the Mourning Dove with this species, or to have been fakes, pure and simple. So far, the reward of $1,000 for a pair of these birds nesting has not been claimed. The writer has been, in the past, familiar with the appearance of the Passenger Pigeon at the time when it was extremely abundant in Minnesota and must confess to having been startled a few years ago in traveling by train from Crookston to Bemidji, at catching a momentary glimpse from the car window of two birds in flight amongst the trees, wonderfully resembling in size, color, and shape, the Passenger Pigeon of yesterday. No opportunity was afforded, how-



The Wild Pigeon

ever, to prove this and he dismissed the idea as absurd.* The glory of discovering the existence (if it does exist) of this former summer resident still remains for some aspiring ornithologist.

There is no need of confusing these two birds. The wild pigeon is 16¼ inches long; the ground dove only 11¾ inches, approximately. The upper parts of the former are dove-colored or bluish-slate with metallic reflections on the sides of the neck of the male, while the upper parts of the dove are grayish-brown. The nests of both consist of small twigs loosely put together and containing in each case two white eggs.

*In this connection it may be noted that Francis L. Palmer of Stillwater, Minn., a student of birds, claims quite emphatically to have observed one of these birds on May 31, 1915, near the above named town, which is in the southeastern part of the state. His observations were published in "Bird Lore" for July-August, 1915, page 289.

THE WOOD DUCK.

The Wood Duck

A bird like the woodcock and some others, rapidly growing more scarce in Minnesota and included here with the Golden Plover as representing our "vanishing birds." Strikingly tropical-looking is the male bird. In the above excellent illustration imagine the sides of the face and soft crested crown, green with purplish reflections, contrasting sharply with the white of the upper throat, the breast a rich, purplish chestnut, finely spotted with white; sides yellowish, delicately penciled with black, with ends of flank feathers sharply barred with black and white. Back blackish or brownish, with green reflections, and long wing feathers, bluish with green reflections. The eye (iris) bright red. A veritable prince amongst ducks, capable of domestication and worthy of most careful protection. What fisherman, wading a wooded stream, or Nature-lover idling on the bank of a secluded pond, has not been delighted by the flashing colors of these beautiful birds as they leave the water, startled at the approach of an alien, or entranced as they disport themselves in sylvan pool, quite unconscious of the admiring glances they invite!

Dr. P. L. Hatch, in his notes on the birds of Minnesota, 1892, voicing his enthusiasm over this duck, breaks into song as follows: "The most truthful and esthetic description of the mature

male could reach no nearer the limning reality than the coldest prose could paint the rainbow. Science, after all her most imposing assumptions, would sit down and weep before the task in black despair. The impotence of all attempts has smirched the skirts of hope by what has been essayed in its systematic, as well as its vernacular nomenclature. *Aix sponsa!* Shades of Linnaeus, weep cold, clammy tears for thine irremedial dereliction! Wood Duck! Summer Duck!"

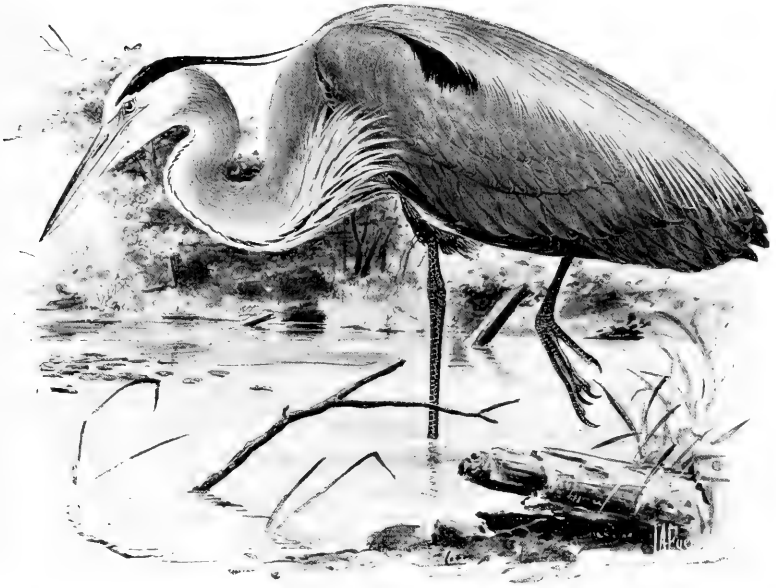
Unlike the majority of ducks, these birds breed in hollow trees overhanging the water. They are typically North American, ranging from Florida to Hudson Bay, but wintering far to the south of our most southern borders. Protected in Minnesota until 1918.

THE GOLDEN PLOVER.

A bird also uncommon, in that it is here irregularly during the migrations, remaining with us only a short time, and now, we believe, rapidly disappearing. The illustration is given here as representing the type. The Killdeer or Ringneck Plover, common in low-lying fields and frequently seen about the barnyard, easily recognized not only by its rather plaintive note but particularly by the black band across the white breast, consumes the larvae of many injurious insects found in pastures and meadows; it eats wireworms, caterpillars, grasshoppers and crickets and the eggs of the two latter.

While with us, the food of the Golden Plover consists chiefly of grasshoppers and other insects. Together with the Upland Plover or Field Plover, another vanishing bird, it is protected in Minnesota until 1918.

THE BLUE HERON.



Another of our wading birds, wrongly referred to frequently as "Crane." The cranes, be it said, are rather birds of the plains and prairies—not of wooded sections, where we find these fishermen abundantly represented. Its food consists of frogs and fish, but grasshoppers and field mice are not scorned. Like the kingfisher, it may become destructive when frequenting the ponds of the fish-breeder.

THE SNOWY OWL AND GREAT HORNED OWL.

Snowy Owl. After Fuertes.

As supplementing a plea in behalf of birds of prey as a class, we introduce here figures and brief notes of two of our owls. The first-named, to be sure, is not a common bird in Minnesota. When seen, it is generally in the winter season, at which time we have occasionally observed it in the bare fields. Our field notes, however, show that this bird was met with occasionally in Otter Tail County in October and November, some years ago. It is, however, distinctly a boreal bird, pushing its migrations southerly only in its search for food.

The Great Horned Owl, however, arriving here sometimes as early as February, is a common bird within our state borders. Rabbits, gophers, muskrats, field mice, and other night-prowling

Great-horned Owl. After Fuertes.

animals represent a large share of the diet of this owl; poultry, too, if farmers allow their turkeys and chickens to roost in tops of trees, on sheds, or on exposed farm wagons. Even skunks (note the illustration) are highly prized by them for food; in fact, when captured, they are frequently strongly scented with skunk odor. With the exception of the skunk, which is ordinarily a useful citizen, the other mammals mentioned must be regarded as injurious—most of them decidedly so; hence this owl is, to a large degree, a benefactor.

LIST OF ANNUAL AND BIENNIAL REPORTS AND OTHER PUBLICATIONS OF THE STATE ENTOMOLOGIST OF MINNESOTA AND OF THE DIVISION OF ENTOMOLOGY, UNIVERSITY OF MINNESOTA, BETWEEN 1895 AND DECEMBER 1, 1916, BOTH DATES INCLUDED.

(List and Index covered by period from 1895 to 1914 compiled by O. J. Wenzel, and published April 4, 1916, as State Entomologist's Circular No. 38.)

REPORTS (Annual, Biennial, or Special)

Some of these publications are still available, but the majority of the editions are exhausted.

1895	1st Rep. *Lugger* (Exp. Sta. Bul. 43)	General insect conditions, Chinch Bug, Locust, etc.
1896	2nd Rep. *Lugger* (Exp. Sta. Bul. 48)	Chinch Bug, Animal Parasites, Mosquitos, Flies, etc.
1897	3rd Rep. *Lugger* (Exp. Sta. Bul. 55)	Grasshoppers and Locusts.
1898	4th Rep. *Lugger* (Exp. Sta. Bul. 61) Special Report *Lugger* (Exp. Sta. Bul. 64)	Butterflies and Moths. Black Rust or Summer Rust (Out of date). The Hessian Fly, Migratory Locusts or Grasshoppers.
1899	5th Rep. *Lugger* (Exp. Sta. Bul. 66)	Beetles.
1900	6th Rep. *Lugger* (Exp. Sta. Bul. 69)	Bugs.
1902	7th Rep. *Washburn* (Exp. Sta. Bul. 77)	General insect conditions, Hessian Fly, Grasshoppers, Chinch Bug, etc.
1903	8th Rep. *Washburn* (Exp. Sta. Bul. 84)	Spraying Methods and Compounds, Nursery Law, Insects affecting Forest Trees, etc.

1904	9th Rep. *Washburn* (Exp. Sta. Bul. 88)	Insects affecting raspberries, blackberries, gooseberries, strawberries, grapes, melons, squashes, cucumbers, Mediterranean flour moth.
1904	Special Report, *Washburn*	Mediterranean Flour Moth.
1905	10th Rep. *Washburn* (Exp. Sta. Bul. 93)	Flies of Minnesota.
1906	11th Rep. *Washburn* (Exp. Sta. Bul. 100)	The Cabbage Maggot and other injurious insects of 1906.
1908	Special Report, *Washburn* (See Bul. 108)	
1907–08	12th Rep. *Washburn* (Exp. Sta. Bul. 112)	General insect conditions, Apple Leaf Hopper, Grasshoppers, Grain Lice, Crown Gall, Tree Insects, Cabbage Maggots, Treehoppers, Black Flies, White Grubs, Stalk Borers, "Jiggers," Bee and Wax Moths, Plant Lice, etc.
1909–10	13th Rep. *Washburn*	General insect condition, cutworms, army worms, grasshoppers, apple leaf hopper, cabbage maggot, San Jose scale, gypsy moth, brown tail moth, household insects, stalk borers, grain plant lice, borers, etc.
1911–12	14th Rep. *Washburn*	General, grasshopper, blister beetles, wheat stem maggot, cutworms, grubs, clover seed chalcid, shade tree pests, typhoid fly, corn bill bug, household insects, mice, rabbits, etc.
1913–14	15th Rep. *Washburn*	General insect conditions, useful birds, spraying, fly control, warble flies, truck crop pests, wire worms, Odonata, Acridiidae, etc.

AGRICULTURAL EXPERIMENT STATION BULLETINS FROM THE DIVISION OF ENTOMOLOGY.

(Exclusive of annual or biennial reports, the first twelve of which appeared as Experiment Station bulletins.)

1888. No. 3. *Lugger* (with Horticulture). Report on the Rocky Mountain Locust in Otter Tail County.

1888. No. 4. *Lugger.* Fungi which Kill Insects Especially as Affecting Chinch Bugs and Locusts.

1889. No. 8. *Lugger.* (Rocky Mountain Locust.)

1889. No. 9. *Lugger.* Insects Affecting Willows and Poplars.

1890. No. 10. *Lugger.* Contains "Syringing with London Purple to Kill Curculio on Our Native Plums"; and "Oak Caterpillars."

No. 16. *Lugger.* Sheep Scrab and How To Cure It.

1891. No. 17. *Lugger.* Migratory Locusts in Minnesota in 1891.

1892. No. 23. The Fruit Fly, etc.

1893. See Special Report.

1893. No. 28. *Lugger.* The Classification of Insects and Their Relation to Agriculture (Out of date).

1899. No. 64. *Lugger.* Black Rust.

1904. No. 37. *Lugger.* The Chinch Bug.

1908. No. 105. *Washburn.* The Importance of the Study of Entomology—How To Collect and Preserve Insects.

1908. No. 108. *Washburn.* The So-called "Green-bug" and Other Grain Aphids in Minnesota in 1907.

1908. See Special Report.

1911. No. 121. *Ruggles & Stakman.* Orchard and Garden Spraying.

1911. No. 123. *Washburn.* Cutworms, Army-worms and Grasshoppers.

1914. No. 141. *Somes.* The Acridiidae of Minnesota (Also continued in 15th Report of the State Entomologist).

CIRCULARS OF INFORMATION.

1908. No. 6. *Washburn.* Crown Gall in Minnesota.
1908. No. 7. *Washburn.* Mediterranean Flour Moth.
1908. No. 9. *Washburn.* Remedies for the Cabbage Maggot.
1908. No. 10. See Press Bulletin No. 32.
1903. No. 11. *Washburn.* Destruction of Lawns by White Grubs.
1908. No. 13. See Press Bulletin No. 33.
1909. No. 14. See Press Bulletin No. 34.
1909. No. 15. *Washburn.* The Cabbage Maggot on Radishes. Work of 1908.
1909. No. 16. *Washburn.* San Jose Scale Possibilities in Minnesota.
1909. No. 17. *Washburn.* Household Insects. A. The House Fly and the Clothes Moth.
1909. No. 18. *Washburn.* The Museum of the Division of Entomology at the Minnesota Agricultural College.
1910. No. 19. *Washburn.* The Danger of Introducing the Gypsy and Brown-tail Moths in Minnesota.
1910. No. 20. See Press Bulletin No. 39.
1911. No. 21. *Washburn.* Household Insects. B. Fleas, Bedbugs, Cockroaches, Carpet Beetles or Buffalo Bugs.
1911. No. 22. *Washburn.* A New Method of Combating the House Fly.
1912. No. 23. *Washburn.* Household Insects. C. Mosquitos, Ants, Silver Fish and Crickets.
1912. No. 24. *Washburn.* The Minnesota Fly-trap.
1912. No. 25. *Ruggles.* Shade-tree Borers.
1913. No. 26. *Washburn.* A. The Minnesota Fly-trap. B. Suggestions for Campaign Against the House Fly, Now Known as the Typhoid-fly.
1913. No. 27. *Washburn.* Twenty Common Insects of the Vegetable Garden and Remedies.
1914. No. 28. *Moore.* Fumigation of Greenhouses with Cyanide.
1914. No. 29. *Moore.* Two Raspberry Pests, Which May Be Controlled By Pruning.
1914. No. 30. *Ruggles.* Some Tree-destroying Insects.
1914. No. 31. *Washburn.* Inspection of Minnesota Nurseries and Imported Stock in 1913-1914.
1914. No. 32. *Washburn.* Useful Birds Found in Minnesota.
1914. No. 33. *Howard.* Control of Flies in Rural Districts.
1914. No. 34. *Moore.* The Cucumber Beetle.
1916. No. 35. *Washburn.* Further Observation on Minnesota Birds; Their Economic Relations To the Agriculturist.
1916. No. 36. *Marcovitch.* The Red Rose Beetle.
1916. No. 37. *Washburn.* Entomologist's Report on Inspection of Minnesota Nurseries and Imported Nursery Stock for the Year 1915.
1916. No. 38. *Wenzel.* Index, Minnesota State Entomologist's Reports.
1916. No. 39. *Williamson.* Some Insect Enemies of Corn. (Special Bulletin No. 8, Agricultural Extension Bulletin.)
1916. No. 40. *Washburn.* Work on White Pine Blister Rust in Minnesota, 1916.

AGRICULTURAL EXPERIMENT STATION PRESS BULLETINS.

1901. No. 12. *Forbes.* The Rocky Mountain Locust.
1901. No. 13. *Forbes.* The Hessian Fly.
1902. No. 15. *Washburn.* A Remedy for the Mosquito Evil.
1903. No. 16. *Washburn.* Criddle Mixture for Grasshoppers.
1904. No. 19. *Washburn.* A Plea for Some of Our Common Birds Based on Their Food Habits.
1905. No. 22. *Washburn.* Insects and Insect-like Animals Attacking Live Stock in Minnesota.
1906. No. 22. *Washburn.* Results of Work of 1905 with Cabbage Maggot. Suggestions To Growers of Cabbage, Cauliflower and Radishes.
1906. No. 26. *Washburn.* An Entomological Calendar.
1907. No. 28. *Washburn.* 1. The Fall Web-worm a Menace in Minnesota. 2. Autumn Remedies for the Stalk Borer in Flower Gardens.
1908. No. 31. *Washburn.* Suggestions To Those Contemplating Spraying.
1908. No. 32. *Washburn.* Insects Affecting Wheat and Other Grains in Minnesota during 1907 and 1908. (Ent. Cir. No. 10.)
1908. No. 33. *Washburn.* Some Destructive Shade-tree Pests. (Ent. Cir. No. 13.)
1908. No. 34. *Ruggles.* Spraying for Plum Curculio. (Ent. Cir. No. 14.)
1910. No. 39. *Washburn.* Grasshoppers and Army Worms in Minnesota. (Ent. Cir. No. 20.)

EXTENSION BULLETINS.

1911. No. 23. *Washburn.* Some Common Insects and Their Control.
1913. No. 42. *Washburn.* Flies and Their Control.
1914. No. 54. *Washburn.* Some Four-footed Farm Pests.

The following leaflets and reprints, many without date, we found in our library files and elsewhere:

The Cottony Maple Scale and How To Destroy It.
Squirrels, Chipmunks and Flying Squirrels.
Sparrow Circular.
Frog Farming.
Pocket or Pouched Gophers.
Skunks.
Black Rust or Summer Rust. *Lugger.*
Gnawers or Rodents.
Gophers.
Insects Injurious to Small Fruit. *Lugger.*
Tent Caterpillars.
Printed letter giving directions for combating chinch bug.

1906. *Washburn.* The Advantages of Hydrocyanic Acid Gas Treatment for the Mediterranean Flour Moth and Other Pests in Flour Mills.
1906. *Washburn.* The Mediterranean Flour Moth.
1909. *Washburn.* Some Minnesota Insects and Useful Birds. (Large chart, colored.)
1913. An Act Providing for the Inspection of Nurseries and Orchards.
1916. Special Bulletin No. 8, *Williamson.* Some Insect Enemies of Corn.

TECHNICAL PAPERS.

1907. *Bruce.* Three New Hymenopterous Parasites of *Pegomyia brassicae.*
1908. *Vickery.* A Comparative Study of the External Anatomy of Plant Lice.

Minnesota Insect Life, a periodical leaflet published by the State Entomologist and Staff, on the first of April, May, June, July and August, of each year, the purpose of which is "to place before farmers, nurserymen, fruit growers, gardeners, housekeepers, and others timely items, which will be of value in suggesting methods for preserving their property from attacks of insects," was first published in June, 1910. Copies of Insect Life are still available except Vol. I, No. 1; Vol. 1, No. 4; Vol. II, No. 7; Vol. II, No. 10.

MINNESOTA NURSERY AND ORCHARD INSPECTION NEWS LETTER.

Vol I, No. 1, Sept. 1, 1915.
Vol. I, No. 2, Dec. 6, 1915.
Vol. I, No. 3, April 20, 1916.
Vol. I, No. 4, May 29, 1916.
Vol. I, No. 5, June 18, 1916.
Vol. I, No. 6, Sept. 15, 1916.

The News Letter, issued at irregular intervals by the Entomologist, purposes to convey to Minnesota Nurserymen news items concerning current work of inspection and interesting facts regarding nurseries, in so far as they relate to our work and are of value to nurserymen.